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ARTERIOVENOUS ANEURYSMS OF THE SCALP AND FACE

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ARTERIOVENOUS aneurysms in the integument may occur anywhere but are more common in the head than over the remainder of the body, and most of these are in the scalp. They are not common; perhaps between 200 and 300 cases have been reported. Elkin (1924) [1] described a case from Cushing's clinic and noted that this was the only case of its kind that Cushing had seen in his entire experience up to that time in over 35,000 patients admitted to hospitals. Nine additional cases are reported; 1 of these was from Dr. Blalock's clinic and is added, with his permission.

Heine (1869) [2] collected the first series of cases of arteriovenous aneursyms occurring in the head, 60 in all, but he questioned the diagnosis in 15. In 46 cases the aneurysms were in the scalp (including twelve back of the ear), in 13 cases they were in the face and in 1 case on the tongue. The first cases in his collection were reported by Pellebon (1810), Walther (1823), Dupuytren (1828), Brodie (1829),[3] Mussey (1830),[4] Graefe (1832) and Breschat (1834). Heine ascribed the origin of most of these tumors to congenital nevi or cavernous angiomas that had been present since birth or had at least been observed soon after birth. From these, the vascular radiations gradually spread and enlarged during the years. A minority of cirsoid aneurysms had no such antecedent lesions but were known to have followed trauma and were presumably related thereto. Virchow was a dominant influence in Heine's interpretation of this lesion as being congenital. There can be no doubt that this view is correct.

Körte (1880) [5] added 26 cases and considered his publication a continuation of Heine's excellent report. He too concluded that most

1. Elkin, D. C.: Cirsoid Aneurysm of the Scalp, Ann. Surg. **80**:332, 1924.

2. Heine, C.: Ueber Angioma arteriole racemosum aus Kopfes und dessen Behandlung, Prag. Vrtljschr. **3**:1, 1869.

3. Brodie, B. C.: An Account of An Aneurysm by Anastomosis of the Forehead, Tr. Med.-Chir. Soc. **15**:177, 1829.

4. Mussey, R. D.: Aneurysmal Tumors upon the Ear, Treated by Ligation of Both Carotids, Am. J. M. Sc. **26**:333, 1853.

5. Körte, W.: Beitrag zur Lehre vom Angioma arteriale racemosum, Deutsche Ztschr. f. Chir. **13**:24, 1880.

of the aneurysms were of congenital derivation but that many were due to trauma; the frequency of the latter was less than that of the former. Since these two excellent pioneer publications by Heine and Körte, many subsequent reports have shown the variations in size and distribution of the so-called cirsoid aneurysms of the scalp and face; some of them are extraordinary. The following are good examples: Müller (1891) [6] described a case in which after operative death the tremendous coils were dissected and photographed; this gave an excellent view of the naked vessels. Berger's (1898) [7] case presented one of the youngest patients (9 years), with an extremely extensive lesion, the great size of which is usually attained in later years. From Germany, large deforming aneurysms were reported by Clairmont (1908),[8] Kepler (1912) [9] and Schlochetzki (1933) [10] and from Holland by Noordenbos and Jong (1918). From England, Canada and Australia, cases have been reported by Brodie (1929),[3] Parker (1904),[11] Searby (1931),[12] Clunie (1936) [13] (aneurysms restricted to the parietal region of one side), Rundle (1938) [14] (aneurysms restricted to the forehead), Davies-Colley (1940) [15] (mass covered the forehead, nose and left eye) and Patey (1942) [16] (mass was largely in occiput); a roentgenogram of one of the enormous vessels was made after injection with iopax (uroselectan). From the United States, cases have been reported by Warren (1867),[17] Mynter (1890),[18] Meyer (1892),[19] Forbes (1895),[20]

6. Müller, H.: Ein Fall von arteriellem Rankenangioma des Kopfes, Beitr. z. klin. Chir. **8**:79, 1891.

7. Berger, H.: Die Extirpation des Angioma arteriale racemosum aus Kopfes, Beitr. z. klin. Chir. **22**:129, 1898.

8. Clairmont, P.: Zur Behandlung des Angiome racemosum, Arch. f. klin. Chir. **85**:549, 1908.

9. Kepler, M.: Zur Behandlung des Aneurysma arteriole racemosum, Beitr. z. klin. Chir. **78**:521, 1912.

10. Schlochetzki, H.: Ein Beitrag zur Pathologie und Klinik der Rankenangiome der Kopfschrootte, Beitr. z. klin. Chir. **157**:35, 1933.

11. Parker, R.: Cirsoid Aneurysm of the Forehead Treated by Free Incision and Extirpation, Brit. M. J. **1**:304, 1904.

12. Searby, H.: Cirsoid Aneurysm of the Scalp, Australian & New Zealand J. Surg. **1**:209, 1931.

13. Clunie, T.: Cirsoid Aneurysm of the Scalp, Brit. M. J. **2**:1183, 1936.

14. Rundle, F.: A Case of Cirsoid Aneurysm of the Scalp, Brit. J. Surg. **25**:872, 1938.

15. Davies-Colley, R.: Cirsoid Aneurysm, Guy's Hosp. Rep. **90**:134, 1940-1941.

16. Patey, D. H.: A Case of Cirsoid Aneurysm of the Scalp, Brit. J. Surg. **29**:290, 1942.

17. Warren, J. M.: Surgical Observations with Cases and Operations, Boston, Ticknor & Fields, 1867, p. 451.

18. Mynter, H.: Extensive Cirsoid Aneurysm of Scalp Obliterated by Multiple Ligatures, Ann. Surg. **11**:93, 1890.

19. Meyer, W.: Excision of Cirsoid Aneurysm of the Temporal Region, New York M. J. **56**:214, 1892.

Coley (1901)[21] (unilateral involvement in the temporal region), Beck (1903)[22] (aneurysms in the forehead, extending over nose and cheeks), Judd (1916)[23] (one of the largest and most widespread aneurysms on record), Elkin (1924)[1] (aneurysm in the front half of the head), Matas (1933),[24] Fite (1933)[25] and Brock and Dyke (1932).[26]

From the early reports of Heine and of Körte, aneurysms back of the ear were in greatest number, but since then those of the scalp have far outstripped them. Perhaps a good index of their frequency is gained from Kepler (1912),[9] who collected 32 cases in the four years after Clairmont's paper (1908).[8] Forty additional cases have been collected in the past ten years, including the 9 reported here. No attempt has been made to cover all the literature. In 32 of these 40 cases, the aneurysms were in the scalp; in 5 cases, they were back of and including the ear, and, in 1 case each, they were in the eye, in the chin (Meleney, 1923)[27] and in the lip (Davies-Colley, 1940).[15] Of the aneurysms in the scalp, eight were unilateral and twenty-four bilateral. The distribution of those in the scalp was: seven largely confined to the forehead (one extending over the nose and eyes; Davies-Colley) and the remaining twenty-five in the parietal or the occipital region or both. All these aneurysms were similar, except in their anatomic expression, to the well known congenital arteriovenous aneurysms that are confined to the brain and which are certainly not less frequent.

One group of these, however, commands special attention and is a type of aneurysm not heretofore recognized; its frequency is attested by the fact that 6 of the 9 cases reported in this paper are of this group (cases 4 to 9 inclusive). The aneurysms in these cases differ from the other aneurysms of the scalp heretofore reported in that the primary arteriovenous aneurysm is in the dura of one or both sides and the extracranial aneurysm arises from numerous perforations of the bone from branches of the dural aneurysm.

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20. Forbes, W. S.: Successful Treatment of a Large Cirsoid Aneurysm of the Scalp, M. News, Philadelphia **66**:663, 1895.

21. Coley, W. B.: Cirsoid Aneurysm Successfully Treated by Excision After Ligation of the External Carotid, Ann. Surg. **34**:414, 1901.

22. Beck, C.: On an Aggravated Case of Aneurysma Racemosum, Ann. Surg. **38**:496, 1903.

23. Judd, E. S.: Cirsoid Aneurysm, St. Paul M. J. **18**:48, 1916.

24. Matas, R.: Cirsoid Aneurysm of the Face and Scalp, South. M. J. **26**:820, 1933.

25. Fite, P.: Cirsoid Aneurysm of the Scalp, South. M. J. **26**:816, 1933.

26. Brock, S., and Dyke, C. G.: Venous and Arteriovenous Angiomas of the Brain, Bull. Neurol. Inst. New York **2**:247, 1932.

27. Meleney, F. L.: A Pathological Study of a Case of Cirsoid Aneurysm, Surg., Gynec. & Obst. **36**:547, 1923.

I have found in the literature only 2 other examples of this type of aneurysm. Both of these were reported by Brock and Dyke in a series of 8 cases of arteriovenous aneurysms of the brain. One of the patients (their case 5) was the same patient that is reported on as case 9 in this series by my colleagues and me; their report was made before the patient came here for operation, and they, of course, could not know of the remarkable intracranial aneurysm that was also present. Their case 4 is identical in every respect with our cases 4, 5, 6, 7 and 8. They commented on the enlarged posterior branches (bilateral) of the middle meningeal artery, and since the patient had a left homonymous hemianopsia they assumed that the enlarged middle meningeal artery contributed the arterial component of an arteriovenous aneurysm that continued into the visual pathways in the brain. The patient also had the same bilateral pulsating aneurysms in the occipital region of the scalp. From the position of these masses in the occipital region on each side, they inferred that the aneurysms were connected with the occipital arteries. However, in the light of the demonstrations of the meningeal connections in our cases, there can hardly be a doubt that their origin was from the middle meningeal arteries and was part of the intracranial aneurysm.

Curiously, in all 5 cases of homonymous hemianopsia the defect of vision has been to the right, the lesion thus being placed in the left cerebral hemisphere. There would appear to be no rational anatomic explanation for this seemingly consistent localization of the aneurysm to the left side of the brain, excluding the right hemisphere. Since the hemianopsia in the case reported by Brock and Dyke was to the left, it is now clear that either hemisphere may be involved in the aneurysm. Needless to add, it would appear to be only a lucky chance that both hemispheres are not invaded, since both meningeal arteries so commonly participate in the dorsal and the extracranial aneurysms.

REPORT OF CASES

CASE 1.—*Arteriovenous aneurysm of eyelids.* A robust man, aged 37 years, entered the hospital because of a large, disfiguring growth in both upper and lower eyelids of the left side (fig. 1 *A* and *B*). He was positive that there had been no swelling or vascular abnormality before he had been struck over the left eye by a steel cable, five years before. The eye was then swollen shut for several days and the lids were discolored, but all the effects subsided. Two months later a small swelling was observed in the left upper eyelid on the inner side; its growth had been progressive. Two years later (three years ago) a similar swelling appeared in the left lower lid, and it too progressed. The swellings were soft and throbbing, but the patient heard no noises. Up to the time of admission, the swelling had been lacerated eight or ten times; following each there was profuse bleeding, and the blood spurted as when an artery is cut.

Examination showed large red swellings of both lids on the left. The eyeball was completely covered, and only laterally was there any indication of a palpebral orifice. The swellings pulsated strongly and synchronous with the radial pulse.

The tumor could be collapsed under a compressing finger, but the pulsation had to be overcome to do it. Especially large vessels stood out at the inner side of the swelling on the left upper lid, which was at the maximum part of the tumor and doubtless was nearest the point of origin of the arteriovenous fistula. Pressure on the common carotid artery stopped the pulsations completely and made the volume of the mass shrink perceptibly. The veins over the left side of the forehead stood out fairly prominently and were tortuous; they ran vertically toward the hair line. A thrill could be felt over both swellings but not over the veins of the forehead.

Fig. 1 (case 1).—*A* and *B*, photographs of patient with the arteriovenous aneurysm in the eyelids. *C*, same patient one year later. The lower lid was largely destroyed in dissecting the aneurysm, and a flap of skin from the forehead was used by Dr. Staige Davis to replace the lower lid.

The conjunctiva (left) was injected, and the eyeball pulsated and protruded 6 mm. The vision in the left eye was 20/50 and in the right eye 20/20. Examination of the fundus of the eye was noncontributory; the veins were not tortuous or engorged. The visual field was normal. The pupil reacted normally. There was no bruit audible over the head.

Impression.—Arteriovenous aneurysm.

Operation.—On April 27, 1944, the internal and external carotid arteries in the neck were ligated. We could not tell whether the arterial side of the fistula was a branch of the ophthalmic artery, a branch of the external carotid artery near the inner canthus or both through collateral circulation. There was not enough protrusion of the eyeball for an aneurysm of the entire ophthalmic artery, i. e., the great swelling was too superficial. The external and internal arteries were exposed and each compressed. Compression of the internal carotid artery reduced the pulsation slightly but definitely. Compression of the external carotid artery almost but not quite stopped it. Compression of both eliminated the pulsation. Three small plugs of muscle (sternomastoid) were inserted into the external carotid artery, and the main trunk was ligated. The internal carotid artery was then tied, and all pulsation ceased. It was noted at the time that the external carotid artery was considerably larger than the internal carotid artery. There were no untoward effects from ligation of these vessels. The reaction to the Matas test, made before operation, was negative and gave assurance that the ligation of the internal carotid artery would be tolerated. It was not expected that this operation would cure the aneurysm, because the vast collateral circulation of the external carotid artery would soon reestablish the pulsation. The ligations were necessary to reduce the circulation to a point where a later excision of the mass would be less hazardous. Without these ligations, I doubt that this vicious aneurysm could have been removed. It would certainly have been a dangerous undertaking.

There was no detectable pulsation of the masses on the following day, but three days later a faint pulsation was detected. The size of both masses was distinctly less (perhaps one fifth) than before operation, and they were softer. A definite palpebral orifice was now present, and the patient could see through the slit without pushing the masses aside.

Second Operation.—On May 6, 1944 both masses were excised. Bleeding was distinctly arterial and troublesome, but complete excision was attained without undue difficulty. Since the arterial pulsation ceased with the ligation of the internal and external carotid arteries, removal of the aneurysm immediately would have been accomplished with less bleeding than would have been obtained ten days later, when the pulsation had returned. The conjunctiva and skin of the upper lid were sufficiently good to get a fair upper lid. On the lower lid, however, the skin was so thin and the conjunctiva so reduced that the lid was largely lost. Much of the remaining lower lid subsequently sloughed from infection. On June 6 Dr. Staige Davis threw a pedicle flap from the forehead to replace the lower lid and obtained an excellent result.

Subsequent Report.—The photograph (fig. 1 *C*) shows the result April 16, 1945, nearly a year after removal of the aneurysm and ten months after the plastic operation.

CASE 2.—*Arteriovenous aneurysm in mastoid region and including the ear.* A white man, aged 39, was a patient on Dr. Blalock's service and was operated on by his resident physician, Dr. Longmire. Ten years before, the patient had noticed a swelling back of the right ear (fig. 2). It steadily grew larger. It was not painful, but there was a roaring hum when he lay on the affected ear. It did not bleed. There was no history of trauma.

The mass measured 2.5 by 1 cm. and involved the posterior surface of the ear in its lower two thirds. It was also attached to the mastoid bone. It was not painful to touch, but a strong thrill was elicited on palpation. A loud hum was heard and was transmitted to the neck.

Operation.—At operation by Dr. Longmire on Feb. 2, 1945, a skin flap was dissected back from the ear, carrying with it the tumor. The tumor was then excised. The superficial temporal artery was also ligated. The patient was discharged one week later; all pulsation had ceased. Fifteen months later there had been no recurrence.

CASE 3.—*Arteriovenous aneurysm of scalp.* N. H., a large, healthy-looking woman aged 29, complained of headache and swelling on the head. The present illness probably dated back to birth, when it was noticed that after a normal delivery the posterior fontanel did not close and a swelling remained there. The patient did not know whether this swelling had increased in size before she

Fig. 2 (case 2).—Arteriovenous aneurysm of the ear and mastoid. This was removed by Dr. William Longmire and has not recurred.

was 20, when her first baby was born, but she did know that after the childbirth the veins began to swell over her forehead and did not recede. Furthermore, with each subsequent pregnancy—and there had been seven—enlargement of the vessels developed anew. The progress of the venous enlargement was from the region of the posterior fontanel along the midline of the head toward the front, then over the temporal and parietal regions of both sides and finally to the mesial side of both eyes. The vessels became painful and tense when venous pressure was increased by straining or coughing or stooping. She also found it more comfortable to sleep with the head elevated. The vessels had never bled. Generalized headaches had been present for four or five years, but only occasionally did they

prevent sleep. Recently there had been a throbbing sensation in both ears, synchronous with the heartbeats; her hearing was unaffected. She had had occasional convulsions. She was again pregnant, for the eighth time.

Examination showed a large mass of vessels in the midline of the scalp, back of the center; from this, huge, tortuous and nodular vascular trunks radiated in all directions (fig. 3 *A*). One large collection passed forward to the bridge of

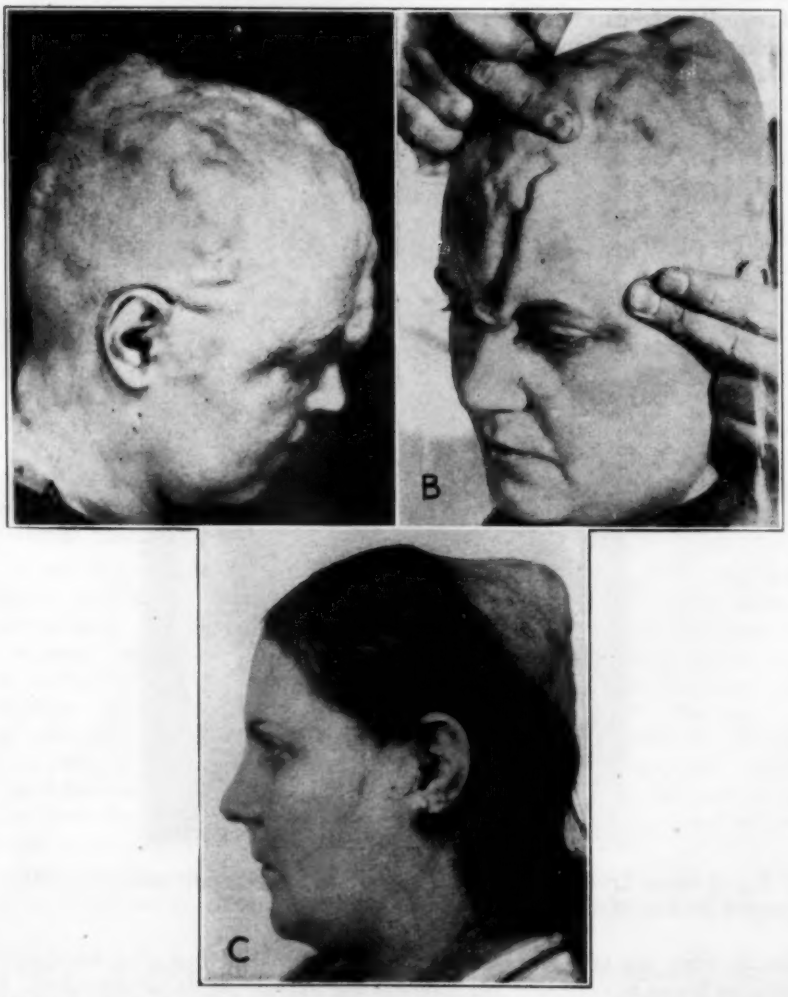

Fig. 3 (case 3).—*A*, patient with extensive arteriovenous aneurysm of the scalp. Note the pronounced swelling in the parieto-occipital region. This is a congenital angiomatous mass from which the large dilated veins emerge to cover the head. The arterial supply of this aneurysm came from two arteries that passed through the skull, one from each middle meningeal artery. *B*, the effect of stripping and compression with the finger of the huge vein passing over the forehead. Since the arterial blood is shut off, the vein remains collapsed. *C*, the same patient five years after ligation of both external carotid arteries. The large veins thrombosed and disappeared after this procedure, but the primary angiomatous mass remains.

the nose and overhung the medial part of both eyes. This mass was slightly bluish. Another mass passed laterally in front of each ear, slightly covering the face. The central mass pulsated strongly; slight pulsation was present in the large vessels radiating from it, and a slight thrill could be detected on light palpation. The central mass was not tender. Compression of the superficial arteries did not influence the size of the swelling. On auscultation a slight murmur was heard; this became intensified with greater pressure of the instrument.

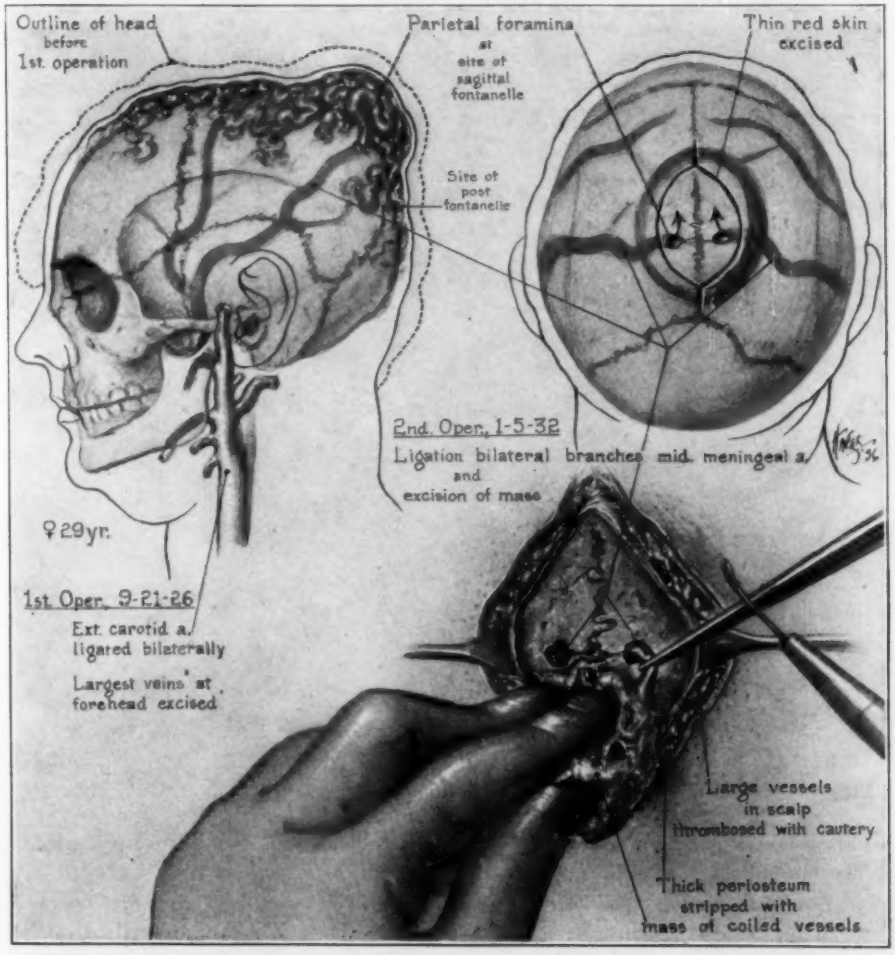
Outline of head before 1st. operation
Parietal foramina at site of sagittal fontanelle
Thin red skin excised
Site of post fontanelle
2nd. Oper. 1-5-32
Ligation bilateral branches mid. meningeal a. and excision of mass
♀29yr.
1st. Oper. 9-21-26
Ext. carotid a. ligared bilaterally
Largest veins at forehead excised
Large vessels in scalp thrombosed with cautery
Thick periosteum stripped with mass of coiled vessels

Fig. 4 (case 3).—Operative sketch showing the two large vessels going through the skull (one from each side) to enter the arteriovenous aneurysm in the scalp.

When the finger milked the blood backward in a big vessel from the nasion to the hair line (fig. 3 *B*), the vessel was collapsed and a deep furrow resulted, indicating that the blood came from the central mass posteriorly. Both middle meningeal arteries were greatly enlarged in the roentgenogram and passed directly backward and upward toward the region of the extracranial angiomatous mass.

Diagnosis.—The diagnosis was congenital ateriovenous aneurysm of the scalp, with a congenital coil of vessels in the midparietal region.

Operation.—On Sept. 21, 1926, the external carotid artery on both sides plus both occipital, internal maxillary and superficial temporal arteries were ligated; the external jugular veins were oversize, and they were not ligated. Temporary compression of the common carotid artery did not appear to influence the size of the mass. The large vein over the forehead was ligated at the hair line. There was essentially no change in the size of the occipital mass; it may even have been a little more tense, and to the patient it seemed definitely tighter (from thrombus formation). The vein over the forehead remained collapsed. Six days later the pulsation in the mass had stopped (from thrombus formation) and the vessels in the mass and those radiating therefrom were firm and pulseless, with the excep-

Fig. 5 (case 3).—Patient after removal of the angiomatous mass. There has been no recurrence since this operation thirteen years ago.

tion of one in the right temporal region. The veins of the forehead had collapsed. The headaches and the noise in the ears were no longer present.

Second Operation.—On Jan. 5, 1932 (five and one-fourth years after first operation), the patient returned because swelling in the back of her head persisted and pulsated (fig. 3 *C*). Except for a fair-sized pulsating vessel in the occiput, there was no trace of the huge veins over the head and face that formerly were so prominent; the central mass was also much smaller. It did pulsate, though much less than before. She wanted to get rid of it.

An elliptic incision was made around a central area of thin red skin at the top of the mass and the mass was dissected from its bed. The periosteum was thickened and was not stripped from the bone. In the layer of thickened periosteum two fair-sized arteries emerging from the parietal foramens were thrombosed with the electrocautery (fig. 4). Since there was no other source for these vessels—

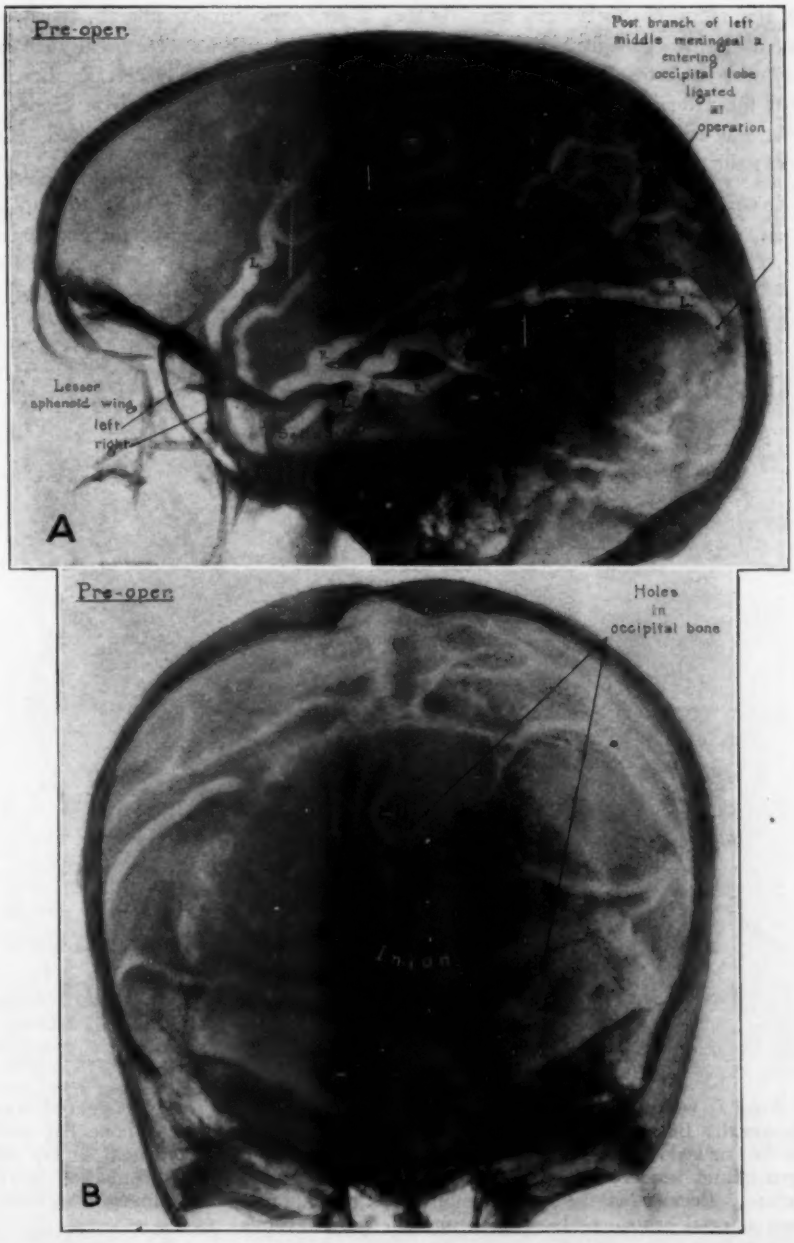

Fig. 6 (case 4).—*A*, roentgenogram showing greatly enlarged grooves of the posterior branch of the middle meningeal arteries on both sides of the skull. These extended to the parieto-occipital region of each side, where numerous branches perforated the skull to form the venous components of the aneurysms in the scalp. (The roentgenogram has been retouched.) *B*, anteroposterior view (case 4) showing numerous erosions in the parieto-occipital region due to perforations of the branches of the middle meningeal artery passing through the skull. (Roentgenogram has been retouched.)

all the lateral channels were severed—they had to come from the bone. It has been noted (in roentgenograms) that the middle meningeal arteries were greatly enlarged and were directed backward toward this mass. It is practically certain, therefore, that the arterial supply of the tumor was ultimately from this source. Since the skin was redundant, primary closure was attained in spite of the excised central area; the wound healed without sloughing (fig. 5).

Subsequent Report.—On June 1, 1945, thirteen years after extirpation of the mass, the patient was perfectly well; there has been no return of the aneurysm.

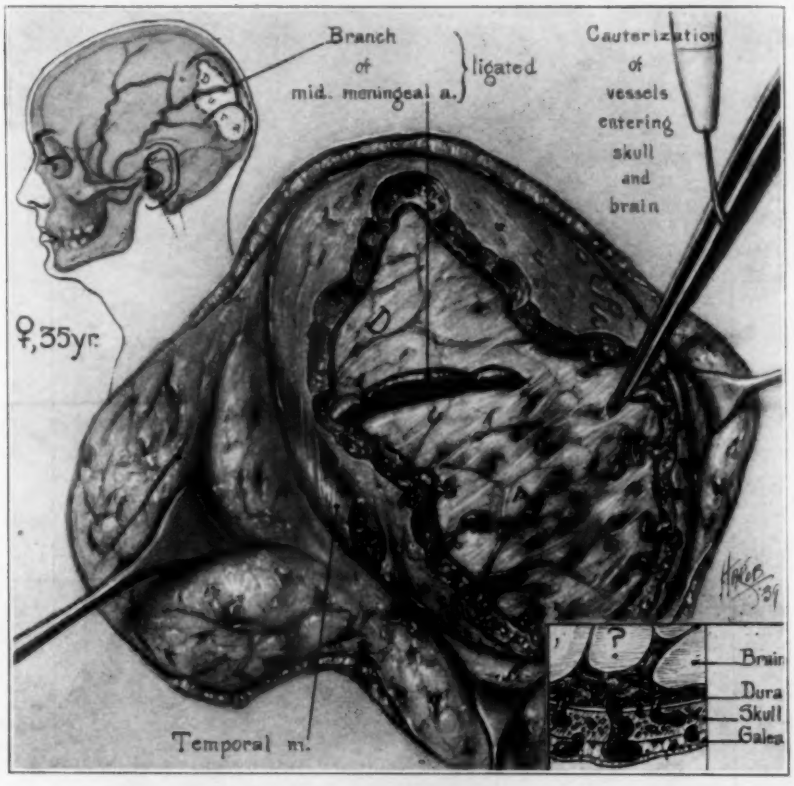

Fig. 7 (case 4).—Operative sketch showing area of bone rongeured away piecemeal. Because of the extensive vascularity in this region, a bone flap could not be turned down safely. An extremely large middle meningeal artery was ligated, and numerous coils of this vessel in the dura were thrombosed by the cautery. Because of the right homonymous hemianopsia, it is almost certain that these arterial branches also passed into the occipital lobe.

CASE 4.—*Aneurysms of the dura, with extension extracranially.*

The patient was a normal-looking woman, aged 38. She complained of headache and noise in the head. She had been conscious of the noise for many years, but the headaches had begun only a month ago. Both the noise and the headaches were in the left occipital region and coincided with a roughly circular pulsating

mass 5 cm. in diameter. There was a similar mass on the right, about half as large as the one on the left. A thrill could be felt and a bruit heard over both masses. The bruit was most intense in the occipital region but could be heard over the entire head and in the neck. The veins over the frontal and the temporal regions were conspicuous.

The patient had a right homonymous hemianopsia.

Roentgenograms showed greatly enlarged middle meningeal grooves extending straight back to the occipital region (fig. 6 *A*). In the parieto-occipital regions of both sides, the bone was extremely porous from numerous small erosions (fig. 6 *B*).

Operations.—On Feb. 13, 1939, an arteriovenous aneurysm in the left occipital region was removed, a flap being used. Arterial bleeding coming out of the bone was controlled by wax. The same operation on the right side was performed Feb. 16, 1939. The bone was not removed on either side. On April 25 the bone was rongeured away piecemeal under the previous flap (left side). The dura

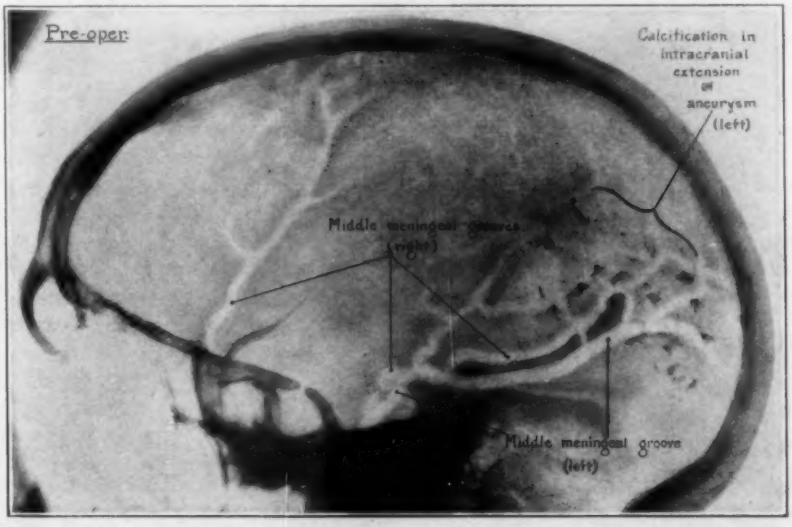
Pre-oper.
Calcification in intracranial extension of aneurysm (left)
Middle meningeal groove (right)
Middle meningeal groove (left)

Fig. 8 (case 5).—Roentgenogram of patient, aged 59 years, showing the greatly enlarged middle meningeal arteries directed backward to the parieto-occipital region, forming in the dura an extensive plexus, the branches of which perforated the skull to form the extracranial arteriovenous aneurysm. The numerous calcifications in the brain doubtless represented the intracerebral extension of the aneurysm and caused the right homonymous hemianopsia.

was extremely bloody, and coils of vessels filled the dura and projected outward toward the bone. They were coagulated with the electric cautery. The large middle meningeal artery was ligated (fig. 7). The dura was not opened.

Subsequent Note.—On May 1, 1945 (six years after the operation), the patient had had no headaches since operation. The aneurysms had disappeared.

CASE 5.—A man aged 59, was rather ill-looking, walked poorly and with staggering gait and was deaf to conversational tones. He complained of general weakness.

Since early childhood he had had intermittent headaches. They were now bifrontal and occurred several times weekly; they were not associated with nausea

or vomiting. For many years a subjective head noise that he could not localize had disturbed him. His hearing had been defective for over twenty-five years, and he had been totally deaf for ten years. He had a right homonoymous hemianopsia but did not know when it developed. Bilateral exophthalmos of moderate degree had also been present for years.

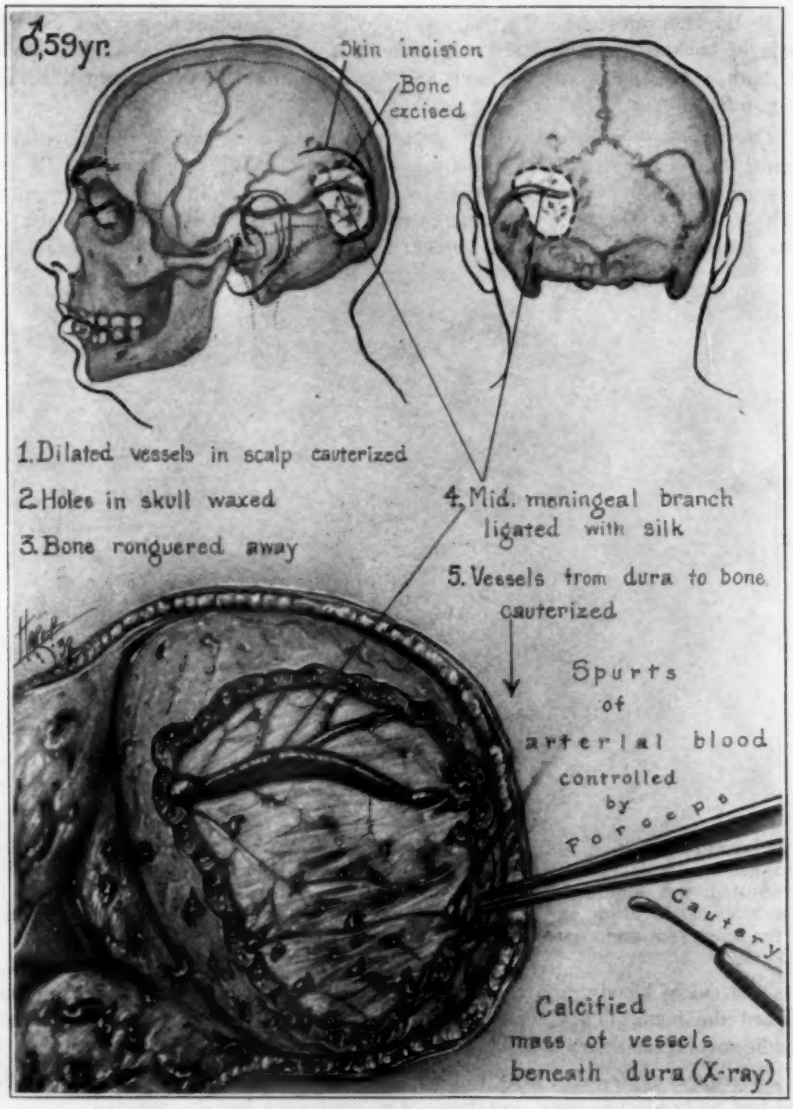
♂,59yr.
Skin incision
Bone excised
1. Dilated vessels in scalp cauterized
2. Holes in skull waxed
3. Bone rongeured away
4. Mid. meningeal branch ligated with silk
5. Vessels from dura to bone cauterized
Spurts of arterial blood controlled by forceps
Cautery
Calcified mass of vessels beneath dura (X-ray)

Fig. 9 (case 5).—Sketch showing operative defect in the bone over the parieto-occipital region, where the greatly dilated middle meningeal artery with its plexus of vessels is exposed. Numerous branches of this plexus perforated the bone and formed the extracranial aneurysm as in the preceding case. This aneurysm also doubtless penetrated the brain on one side and produced a right homonymous hemianopsia, and the numerous calcifications in this region are almost positive evidence of deposits in the vessels in the brain.

A year before he had begun to have general malaise and weakness and had difficulty in walking, especially in the dark (due to vestibular divisions of the auditory nerves). His wife said that he was becoming mentally sluggish, was disoriented at times and on numerous occasions had threatened suicide. There had been no convulsions.

Examination.—Examination revealed: (1) in the left occipital region an expansile, pulsating mass, 5 cm. in diameter (a systolic thrill could be heard over it); (2) in the right occiptal region another mass of same kind but smaller, 3 cm. in diameter; (3) in the right vertex another similar mass (2.5 cm. in diameter); (4) over both temporal regions many tortuous pulsating vessels; (5) right homonymous hemianopsia; (6) bilateral exophthalmos; (7) bilaterally equal loss of hearing below conversational level; (8) bilateral vertical nystagmus; (9) swaying broad-based walk, with a positive Romberg sign in all directions; (10) roentgenologic evidence of enormous bilateral middle meningeal channels, directed backward to the occipital region and numerous little erosions in parietal bones, and of several small calcified areas in the left parietal and occipital lobes (fig. 8), and (11) stopping of the pulsation on the corresponding side by pressure on the carotid artery.

Operation.—On April 11, 1939, an occipital extracranial aneurysm on the left side was excised, a flap being used. From the bone, arterial blood spurted in dozens of places; it was controlled by waxing.

On April 19, under the cutaneous flap, the bone was rongeured away piecemeal. Dozens of little vessels were pulled out of the bone; many were thrombosed, but some still bled; they were attached to the dura and were continuous with the branches of the middle meningeal artery. This vessel was as large as a slate pencil and was ligated (fig. 9). The many bleeding points in the dura were coagulated with the cautery. The dura was not opened.

The patient was much improved on Dec. 12, 1939. His headaches were now only on the right side; he was much better mentally. The neurologic conditions had, of course, not changed. The middle meningeal artery was tied on the right subtemporal approach.

Comment.—This case is very similar to the preceding one in many of the subjective and the objective findings. On July 20, 1945, six and one-fourth years after operation, the patient was free of all headaches and leading a normal life.

CASE 6.—A pale, undernourished man, aged 46, had never been well; he had always been easily exhausted and had had numerous complaints. Generalized headaches had begun fifteen years before consultation and were intermittent until one year before he was seen, when they became constant. Since losing a good job five years before, he had been nervous, depressed and subdued and had had a definite personality change. For six weeks there had been an occasional noise in the right ear. His complaints were those characteristic of psychoneurosis. However, for the past two months he had had intermittent attacks of numbness in the left arm and leg but no actual convulsions. The examination disclosed numerous large dilated and tortuous vessels in the scalp, over which a thrill could be felt and a murmur heard. These were more pronounced in the occipital region, the vertex and both temporal regions. There was no concentrated mass of vessels as in other cases. There was a small hemangioma on the right upper eyelid and a birthmark in the midline of the upper lip, neither associated with the vascular masses.

The roentgenogram showed three small calcified areas in the leg area of the right side—doubtless the cause of his sensory seizures (fig. 10).

Operation.—On July 31, 1942 a bone flap was contemplated to remove the calcified areas in the right hemisphere, but the bone was covered with tiny holes from which arterial blood spurted and was controlled by wax; the sharp bleeding was from the vessels supplying the extracranial arteriovenous aneurysms. Continuation of the bone flap would have courted severe hemorrhage. Instead, the bone was rongeured away by bits, and each bite of the bone was attended by brisk bleeding. The exposed dura was covered with large vessels, branches of the middle meningeal artery; these were coagulated with the electrocautery. The

Fig. 10 (case 6).—Anteroposterior roentgenogram showing calcifications along the falx. These calcifications were not subjacent to the aneurysm but were independent of it. They were causing the epilepsy and were not related to the arteriovenous aneurysm.

dura was turned back and three small bony spicules removed from the brain in the neighborhood of the longitudinal sinus; one was flat and on the surface of the pia, and each of the other two was perhaps 2 cm. in length and projected into the brain tissue. All were easily removed. In this limited exposure the suspected intracranial aneurysm was not visible.

CASE 7.—A normal-looking man, aged 42, had had headaches for fifteen years; at first they had occurred every two or three months, lasting from a few hours to a day, and had ended with vomiting. For the past two years the headaches had been almost constant. They were mainly on the left side and affected the eyes, the face, the gums and the back of the head and neck. A visual aura had preceded the attacks; blindness lasted from thirty to forty-five minutes when headaches followed, but there were many attacks of blindness without headaches; the blindness then lasted longer, thirty to forty-five minutes. At times there was numbness of the left hand, and at times there was difficulty in expressing himself and naming objects.

Examination.—1. There were enlarged tortuous vessels over the left parietal and occipital regions, but there was no visible or palpable localized mass of vessels. 2. A bruit was heard over the entire skull, but it was more pronounced in the left parietal and mastoid regions. 3. There was a homonymous hemianopsia to the right. 4. A roentgenogram of the skull showed a greatly enlarged left middle meningeal artery directed backward to the left occipital region (fig. 11). This

Fig. 11 (case 7).—Roentgenogram showing the large middle meningeal grooves extending to the parieto-occipital region where the arteriovenous aneurysm presented extracranially. (Roentgenogram not retouched.)

involved only the posterior branch of the middle meningeal artery, the anterior branches being normal. 5. There was a small diffuse area of calcification in the depths of the parietal lobe.

Operation.—On Dec. 30, 1944 both middle meningeal vessels in the parietal region were ligated.

The patient returned because of continued headaches and a second operation was performed, Nov. 1, 1945. The parieto-occipital region on the left side was rongeured away piecemeal, as in the other cases, until a defect as large as the palm of one's hand was made. There was no undue bleeding from the bone except in the mastoid region, which was extremely bloody; here the bone was stripped and waxed, as in the other cases. The dura was turned back over the entire area; there was intracranial pressure of high grade, the brain bulging tremendously. A large arteriovenous aneurysm covered much of the temporal and parietal lobes; it extended from the inferior surface of the temporal lobe, covered

in lesser degree the parietal lobe and emerged at the mastoid region, where the dural and extracranial connections were made.

Subsequent Course.—The patient has just left the hospital. His headaches had ceased; relief of the intracranial pressure was due to the large decompression.

CASE 8.—A white woman, aged 31, was referred to me by Dr. Charles Wainwright, of Baltimore. Her first complaint was dimness of vision, beginning six years before and occurring only at times, but it had been so disturbing that an ophthalmologist was consulted. At this time she was said to have had bilateral papilledema and was referred to a neurosurgeon, who on three occasions attempted injection of air via the ventricles and the spinal canal, but without successful filling of the ventricular system. Following these procedures, headaches first appeared and were attributed by her to the punctures. The headaches had been confined to the left side. There was a sensation of fulness and a dull aching, and both were practically continuous, though with variations in degree. Injections of histamine did not

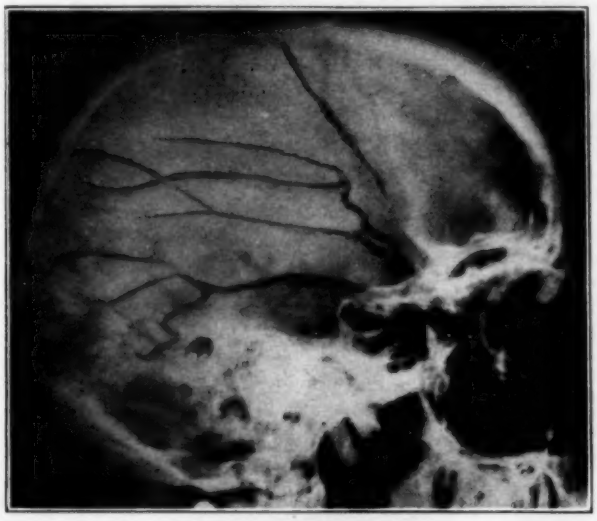

Fig. 12 (case 8).—Roentgenogram (not retouched) showing the enlarged posterior branches of the middle meningeal arteries on both sides. On the left side, the branches ultimately form a network.

influence the headaches. She had had two hospital admissions to Dr. Wainwright's service, June 30, 1943 and July 18, 1945. Since her first admission she had had four convulsions; three of these were in rapid succession.

Examination.—The patient was well developed and well nourished. The only significant finding was a homonymous hemianopsia for form and color on the right side. On three occasions the Wassermann test of the blood elicited a positive reaction, and, on the assumption that there was a cerebral syphilitic process, she had received antisyphilitic treatment for eighteen months.

The roentgenogram showed bilaterally symmetric, large posterior branches of the middle meningeal arteries; these were directed backward toward the occipital region and were considered pathognomonic of an arteriovenous aneurysm of the dura (fig. 12). Following this interpretation, auscultation disclosed a murmur over most of the head but of greatest intensity over the parieto-occipital region and

more on the left side. No mass could be felt, but after the head was shaved, preparatory to operation, a soft boggy mass was palpable mesial to the left mastoid; this pulsated strongly, and there was a thrill. There were no intracranial calcifications and no evidence of porosity of the bone in the roentgenogram.

The patient had been extremely emotional. She "cried every day" and after a "good cry the headache was always better." But a psychoneurotic headache would not have been localized to one side of the head.

Operation.—On July 26, 1945, a semicircular flap of scalp was turned back in the parieto-occipital region. Bleeding from the bone was furious; dozens of spurting vessels were waxed after the bone had been scraped. As in the preceding cases, a bone flap could not be considered, because of the excessive vascularity. This

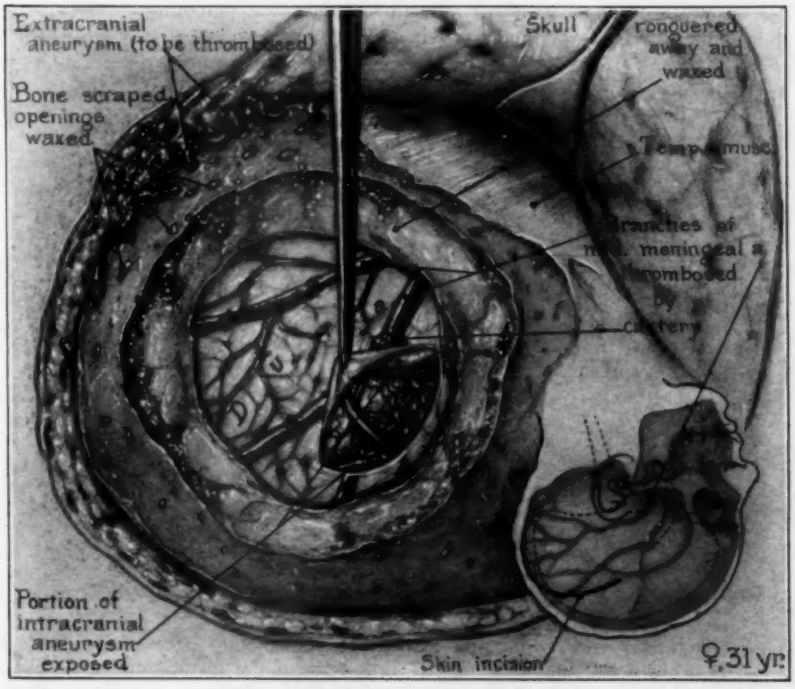

Fig. 13 (case 8).—Operative sketch showing the defect in the bone, the large middle meningeal artery and branches and a small exposure of the intracranial aneurysm.

area of skull was rongeured away piecemeal until dura, about 5 by 5 cm., was uncovered. The middle meningeal trunks were large, and these and numerous spurting branches in this membrane were thrombosed with the electrocautery. The bone was quickly waxed after each bite was removed. A small opening was made in the dura, and a small dural flap was begun but not completed because of bleeding. Large vessels of an arteriovenous aneurysm covered the brain (fig. 13). The exposure was too small to determine the arterial connections of the aneurysm.

Case 9.—A youth, aged 19, was referred to me by Dr. M. Douglas, of Harrisburg, Pa., Aug. 29, 1933, because of a midline pulsating swelling on the forehead

(fig. 14). (This case was reported by Brock and Dyke [1932], but before the operations.)

Present Illness.—The father had noticed a bean-sized swelling at the root of the nose when the boy was 2 or 3 years old. The tumor had grown slowly and steadily, and when the boy was 6 it was the size of a thumb and was then known to pulsate. Aside from a rushing noise in the head, there had been no symptoms. There was an indefinite history of a bump on the head when the boy was 2, but the parents could not suggest a definite relationship to the onset of the tumor. The patient had never had convulsions.

Examination.—The tumor was in the exact midline of the forehead and extended from the hair line to the bridge of the nose; it measured 5 cm. in length and 3.5 cm. in width and was elevated about 2.5 cm. It had a bluish tinge and pulsated strongly, and a pronounced thrill was imparted to the palpating finger. At the bridge of the nose the swelling was not so high but extended to the inner canthus

Fig. 14 (case 9).—Photographs of patient before and after removal of the arteriovenous aneurysm in the forehead. The scar of the intracranial exposure of the aneurysm is also shown in the postoperative photograph.

of the eye and gave the impression of a rather wide nose and of the eyes being farther apart than normal. There were small telangiectases over the eyelids and some on the face.

Pressure on either internal carotid artery did not eliminate the pulsation. On palpation, one had the impression of entwining vessels.

On auscultation, a murmur was heard over the mass and over the whole head and down both sides of the neck. The only positive neurologic findings were (1) general constriction of the fields of both eyes, (2) nasal hemianopsia on the left, (3) left homonymous hemianopsia for blue only and (4) reduction of visual acuity on the left to 20/50; the visual acuity on the right was 20/20.

The roentgenogram showed multiple thin, straight and curved calcified linear shadows, suggesting plaques, in walls of blood vessels (fig. 15). The frontal bone was extremely thin.

Impression.—The intracranial calcifications and the partial homonymous hemianopsia made an intracranial lesion certain. And since the extracranial lesion was an arteriovenous aneurysm, it was practically certain that the intracranial lesion would be of the same character.

First Operation (Aug. 30, 1933).—A left anterior craniotomy, exposing the frontal lobe and extending close to the longitudinal sinus, was performed. The bone flap was extremely bloody; this had been anticipated because of the large middle meningeal artery shown in the roentgenogram. When the dura was turned back, an arteriovenous aneurysm so completely covered the entire exposure that

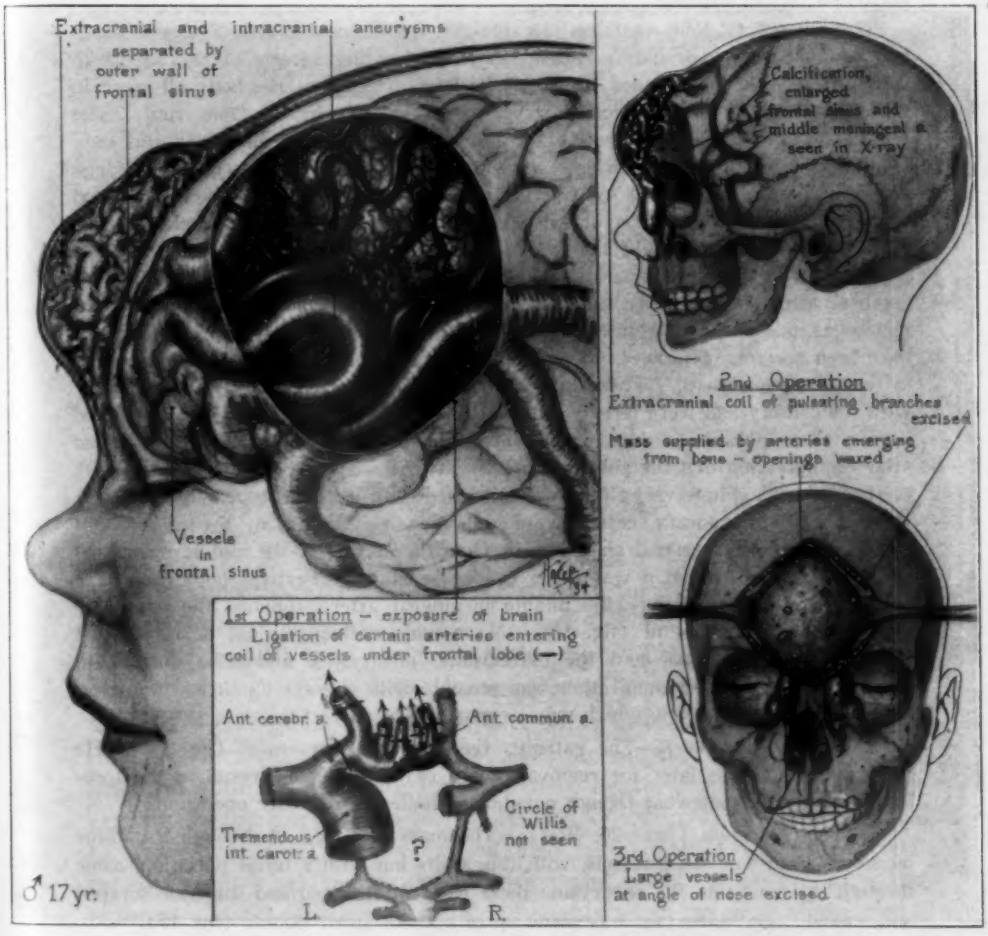
Extracranial and intracranial aneurysms separated by outer wall of frontal sinus
Vessels in frontal sinus
Calcification, enlarged frontal sinus and middle meningeal a. seen in X-ray
2nd Operation
Extracranial coil of pulsating branches excised
Mass supplied by arteries emerging from bone – openings waxed
1st Operation – exposure of brain
Ligation of certain arteries entering coil of vessels under frontal lobe (—)
Ant. cerebr. a.
Ant. commun. a.
Tremendous int. carotid a.
?
Circle of Willis not seen
L.
R.
3rd Operation
Large vessels at angle of nose excised
♂ 17yr.

Fig. 15 (case 9).—Operative sketch showing the enormous intracranial venous aneurysm and the smaller extracranial aneurysm on the forehead. No connection between the two could be demonstrated. The huge vessels in the intracranial aneurysm carrying arterial blood are the largest I have ever seen in the brain. The lower left inset shows the group of vessels that were ligated in the hope of eliminating the arterial circulation to the aneurysm. The lower right inset shows the perforations in the bone that fed the extracranial aneurysm. These vessels are derived from the middle meningeal artery, a sketch of which is shown in the upper inset.

little brain tissue was visible. One enormous vessel, pink from arterial blood, skirted the posterior part of the exposure and curved forward toward the tip of the frontal lobe. A second vessel, of similar size, curved backward toward the temporal lobe, where it was lost to view. These two vessels were much the largest vessels I have ever seen in the brain. They were as large as one's little finger and pulsated violently. The walls were fairly thick but not so much as those of an artery (fig. 15). Numerous large coiled vessels covered the frontal lobe. Three large vessels crossed to the longitudinal sinus and were thrombosed with the electrocautery and divided. A mass of vessels extended to the tip of the frontal lobe but could not be traced through the bone, i. e., to connect with the aneurysm on the forehead.

The left frontal lobe was then elevated and the internal carotid artery exposed and isolated. Perhaps half a dozen fair-sized crossing vessels of the aneurysm were thrombosed and divided before the carotid artery was reached; all were in the neighborhood of the carotid artery and completely hid it from view. The internal carotid artery was the largest I have seen before or since and was only slightly smaller than the enormous vessels on the surface of the aneurysm. The anterior cerebral artery, at least twice as large as normal, was doubly clipped and divided and the ends coagulated with the cautery; four large branches of this vessel extending to the right side were also thrombosed and divided (fig. 15). It was our belief that the arterial supply of the aneurysm was from the anterior cerebral artery, and it was our plan to remove the arterial component as completely as possible. This interpretation of the arterial supply may or may not have been correct. However, after these ligations the pulsation in the large trunks in the aneurysm ceased. These huge vessels on the surface were then coagulated with the cautery and were largely obliterated. This could not have been attempted during their pulsation; they would surely have ruptured. It was also noted after the operation that the pulsation in the extracranial aneurysm was absent. On the following day, however, a faint pulsation had returned, and it steadily increased. Whether this temporary cessation of pulsation resulted from the absence of pulsation in the intracranial aneurysm or from the cutting of the middle meningeal artery when the bone flap was made cannot be stated. Perhaps both may have been responsible. Certainly the middle meningeal artery supplied the aneurysm directly through the skull (fig. 15). No actual continuity could be established between the intracranial and the extracranial aneurysms, and it is difficult to believe that such a communication was possible with the skull intact. However, this is only an impression, which may or may not be correct.

Postoperative Course.—The patient's recovery was uneventful (fig. 14). He returned ten months later for removal of the extracranial aneurysm on the forehead. This was somewhat though not much smaller than before operation.

Second Operation (June 20, 1934).—The mass was excised through a midline incision. Four fair-sized vessels, with thin walls but with arterial pulsation, came through the bone into the aneurysm; these were thrombosed and the bone scraped and waxed. The aneurysm was made up of coils of small vessels (fig. 15).

Third Operation (June 27, 1934).—Since a fulness remained at each side of the nose and extended toward the inner canthus of the eyes (fig. 15), an additional extirpation of these portions was thought to be indicated to improve the appearance. On June 27 this was done on the left side, but the procedure was so bloody that the operation on the other side was not done. I am still perplexed to explain the existence of such a vascular mass after the aneurysm on the forehead had been excised.

Subsequent Course.—The patient was discharged from the hospital July 18. The extracranial aneurysm did not return.

On Jan. 2, 1937, two and one-half years later, his death was reported, "cause unknown." Six months before death, convulsions had developed.

In retrospect and with a more extended experience with these lesions, I doubt that the operative attack on an intracranial aneurysm of this type is indicated. It is extremely unlikely that the entire arterial supply of such an aneurysm could ever be completely eliminated, because of the extensive collateral circulation. In none of the other cases has the intracranial aneurysm been molested, and in only 2 has it been exposed.

COMMENT

This group of aneurysms, together with those reported on in the literature, indicates clearly that there are two sources of origin. Most of them arise congenitally, but many develop in the later years of life from trauma and without a preexisting vascular lesion. In only 1 of our 9 cases is the aneurysm known to be traumatic in origin (case 1). In case 2 it may or may not be of traumatic origin, but it is more probably from a congenital nevus, though it was not recognized. In the remaining 7 cases they are known to be congenital in origin. In the traumatic cases, it can only be said that as a result of the injury an arteriovenous connection has been established between small arteries and veins. Although there are certain sites of predilection for the congenital aneurysms, particularly the scalp and the back of the ear, they may occur almost anywhere.

In this series of 7 cases of arteriovenous aneurysms of the scalp, it is clearly shown in all that the arterial component is derived from the middle meningeal artery and therefore that the arterial blood comes through the skull from the cranial chamber. This statement does not mean that all such aneurysms have intracranial connections, but it does indicate the frequency of this source of arterial supply and, I think, it also indicates that this is the usual if not the sole origin. This intracranial arterial supply explains why ligations of any and all the arteries in the scalp make no impression on the pulsation or the size of the extracranial aneurysm and also why ligation of the external carotid artery does reduce the pulsation and size to some extent. The external carotid artery cuts off blood supply from the middle meningeal artery. When both external carotid arteries are ligated—and this can be done with impunity—the pulsation of the aneurysm is completely stopped, but the effect is only transient because of the extensive collateral circulation that obtains.

There are two types of arteriovenous aneurysms of the scalp (fig. 16): (1) that in which one, two or perhaps more preformed genuine arteries come through the skull and enter a primary congenital

angiomatous mass on the exterior (in case 3 the arteries passed through the parietal foramens, one on each side) and (2) that in which numerous thin-walled vessels penetrate the skull and form an arteriovenous bed without a primary angiomatous mass in the scalp (cases 4, 5, 6, 7, 8 and 9 are of this type). In the latter group the arteriovenous bed in the scalp is smaller; at least in none of these cases has it approached the size of the beds in the first group, and in 1 case it was demonstrable only after the head was shaved. In 5 of the 6 cases in this group an arteriovenous component of the aneurysm was also in the cerebral hemisphere. Whether or not this ever obtains in the first group cannot be stated; it has never been demonstrated, and because of the great size of the extracranial aneurysms my guess would be that there are no intracranial components. Both types are prone

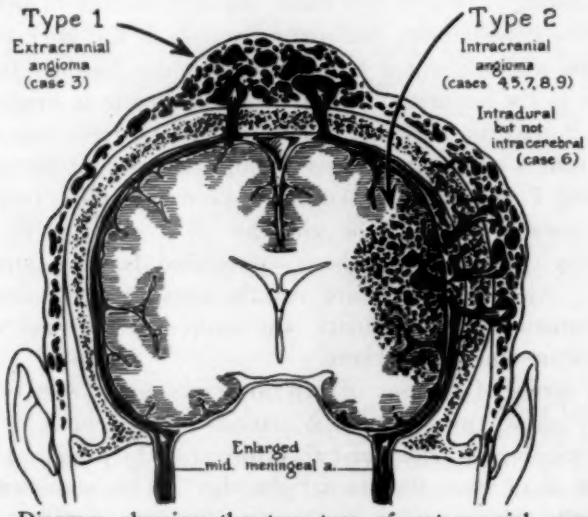

Fig. 16.—Diagram showing the two tyes of extracranial aneurysms, both arising from the middle meningeal artery. In type 1 the extracranial aneurysm is supplied by preformed arteries coming through the skull and entering an angiomatous mass, and in type 2 there are numerous branches of the middle meningeal artery penetrating the skull over a wide area and forming the arteriovenous aneurysm extracranially. In type 2 the aneurysm usually but not always extends into the cerebral hemisphere.

to have a bilateral arterial supply from the middle meningeal arteries, but in some it is unilateral and in most it is greater on one side than on the other. In the second group, the vessels penetrating the bone are so thin walled that they are not recognizable. When the galea is turned back, they rupture at the bone and are controlled by waxing. The bleeding is so furious that wax must be applied quickly and in large amount. In the first group the vessels were preformed and the firm walls permitted their isolation and control by ligatures. The diffuse vascularity of the bone in the second group is similar to that

arising from the highly vascularized dura that develops over dural meningiomas.

The perforations in the skull from these vessels frequently show in the roentgenogram, and in 1 case the affected region of the skull appeared moth eaten from the vascular perforations. Moreover, in these 6 cases the great arterial varices in the dura were seen after removal of the bone; in every case (except case 7) the bleeding was too severe to warrant turning down a bone flap; instead, the bone was removed piecemeal with rongeurs. In 6 of the 7 cases the grooves in the oversized middle meningeal arteries were strikingly shown in the roentgenogram and were directed backward to the vascular bed in the skull. In all but 2 of our cases the aneurysm was in the parieto-occipital region (in case 7 it was in the temporal lobe), and it is the enlargement of the posterior branch (normally inconspicuous) that is all-important in the roentgenologic diagnosis of this lesion. In 5 cases, both the right and the left meningeal arteries were about equally enlarged, although the size of the extracranial aneurysm varied on the two sides, and always the hemianoposia indicative of the intracerebral aneurysm was unilateral.

In 5 of these cases there is proof that the brain was also involved in the aneurysm, for in each there was a right homonymous hemianopsia, which could be explained only by the invasion of the visual area in the occipital or temporal lobes by the aneurysm directly overlying it. In 3 cases (cases 5, 7 and 9) numerous calcifications in the brain indicated the extension of the aneurysm into the subjacent brain. These have been linear in 2 cases and diffuse in the third; the linear shadows suggest calcification of walls of blood vessels. The fact that epileptic attacks have been reported in at least 6 cases in the literature, 1 of Clairmont's (1908), 1 of Elkin's (1923) and 4 of ours, is suggestive but not conclusive evidence of a cerebral extension of the lesion. In 1 of our patients (case 6) in which the cerebral hemisphere was exposed, the seizures were not due to extension of the aneurysm into the brain but to three dense bony plaques of congenital origin. Moreover, these plaques were at a distance from the site of the aneurysm in the dura and not subjacent, as in case 5. Since congenital lesions are not infrequently multiple and of different types, an intracranial extension of an aneurysm cannot be accepted purely on the basis of convulsions; the aneurysm may or may not be responsible. The 5 cases with right homonymous hemianopsia, however, could leave no doubt concerning the intracerebral extension of the aneurysm and of the convulsions when they were present. The intracranial aneurysm was demonstrated in 3 cases at operation. In the case of 1 patient with an enormous intracranial aneurysm, there had never been convulsions;

he was 19 years old. However, convulsions finally developed before his death, two and one half years after operation.

The large middle meningeal arteries directed toward the location of the angioma have been commented on by Clairmont (1908),[8] Elkin (1923)[1] and Rundle (1938),[14] and all considered the possibility of this source of the arterial blood. Elkin and Cushing, who operated on the patient, concluded it to be "a mistaken idea," and in a recent communication to me Elkin still maintained this view. Elkin stated that Guerin (1870) suggested the possibility that the lesion might extend intrancranially. In looking at Cushing's operative sketch in the paper by Elkin it should be perfectly clear that the arterial blood does come through the bone and therefore from the middle meningeal artery, because the central mass of the aneurysm is encircled by the incision and could therefore get no possible arterial blood from the scalp; since the vessels still bled briskly, the blood had to come through the skull. Moreover, Cushing did not separate the vascular mass from the skull but was content to make numerous ties of the protruding vessels. In such circumstances, a cure, if it resulted, could have come only from extension of thrombus formation resulting from the ligatures, a not impossible outcome. In a recent letter Elkin stated that the patient was cured. A photograph of the patient after operation, however, still shows a swelling at the original site; Elkin explained this as edema of the tissues.

It is difficult to believe that such large and misdirected middle meningeal vessels do not carry pathognomonic significance concerning the arterial supply of the aneurysm, and in our direct exposure of these vessels in the 7 cases this conclusion is inescapable. In 1 case (case 8) the diagnosis was made solely on this finding in the roentgenograms, and this led to the discovery of the murmur and the extracranial aneurysm.

It is worthy of comment that all these patients have been highly nervous, and after cure of the headaches and the head noises the nervous condition, while improved, has continued in most cases.

A review of the relative size of the extracranial component in the 7 cases of arteriovenous aneurysm of the scalp leads us to believe that the size of the extracranial aneurysm is probably inversely proportional to the size of the intracranial component of the aneurysm, i. e., when the extracranial aneurysm is small, the intracranial portion is extremely large and when the extracranial part is large the intracranial part, if any, is small. This has at least been true in the cases reported here.

THE TREATMENT

In recent years, with improved hemostasis, most of the patients have been treated by extirpation, with little mortality. Even in the past

century there were many successful extirpations, usually, but not always, in two or three stages. During the past century, however, many aneurysms were injected with corroding solutions or treated by galvanic punctures, with a surprising number of cures. The end result was attained by thrombosis of the vessels, after which the mass gradually disappeared. However, in most instances there was only improvement and frequently only for a time; one or more repetitions of the treatments brought the final disappearance of the lesion. In many cases severe infection followed the injections, and this at times induced the cure by thrombosis; but a rather large number of deaths resulted from the infections. Kümmell (1883)[28] reported six deaths in 15 collected cases in which injections had been used. The fact that severe "inflammation" helped the disappearance of the aneurysm was even recognized in the period before Lister's discovery of the cause of infection. Cures by injections are still occasionally reported. Fite (1933)[25] reported a cure by injections of boiling water. Patey (1942)[16] tied both external carotid arteries and cured the aneurysm by injections. Klass (1942),[29] using sclerosing injections, brought about the complete disappearance of a large aneurysm involving the ear; had the mass been extirpated, two thirds of the ear would have been sacrificed. Davies-Colley (1940)[15] reported a remarkable cure of a big aneurysm of the forehead and covering the bridge of the nose and an eyelid; the cosmetic result was doubtless better than by operation, since no scar remained; in another of Davies-Colley's cases, the patient died twenty-eight hours after an injection. One cannot deny the value of injections, and doubtless in experienced hands the risk is not great; moreover, there are times when the cosmetic results will be better. In safe hands, however, and certainly for aneurysms back of the hair line, surgical removal is better and safer.

During the nineteenth century, ligation of the common carotid artery, even on both sides, attained a great vogue. It is difficult to understand why the common carotid arteries should have been ligated instead of the external carotid arteries, from which the blood supply is derived and the ligation of which is harmless. The summarized results of Heine (1869)[2] and Körte (1880)[5] show this procedure to have been almost routine. The size of the aneurysm was always reduced by the ligations, but within a short time the pulsation had returned and the lesion continued to grow. As a matter of fact, ligation of the common carotid artery can carry less effect on these aneurysms than ligation of the external carotid artery because the return flow

28. Kümmell, H.: Zur Behandlung des Angioma arteriole racemosum, Arch. f. klin. Chir. **28**:194, 1883.

29. Klass, A. A.: Cirsoid Aneurysm Affecting Auditory Auricle, Canad. M. A. J. **46**:370, 1942.

of blood from the internal to the external carotid artery quickly overcomes the transient effect of closure of the common carotid artery. And it should again be noted that a number of hemiplegias and deaths followed ligations of the common carotid arteries. Ligation of any of the large arteries in the neck probably never cures an aneurysm and can improve it for only a short time. Thrombosis could conceivably result from such ligations and thus produce a cure, but so many failures are recorded that one is led to suspect that thrombosis occurs mainly through the venous components of the aneurysm. In our case, ligations of the external carotid arteries plus one large vein in the scalp produced widespread thrombosis that cured all the emissary vessels from the aneurysm and even reduced the angiomatous mass.

One can only marvel at the results attained by surgical treatment before Lister made open operation safe and at a time when hemostasis was far less secure. The cure of a large aneurysm of this type in 1829, by Benjamin Brodie, one of the great names in English surgery, provides most interesting reading of one of the earliest cases treated by surgery. This patient had been seen by Sir Ashley Cooper, probably the most famous surgeon in the world at that time. He had treated her with compression bandages, without result. Since the lesion was growing steadily and causing much discomfort, he yielded gracefully to Brodie's suggestion of a surgical attack that Brodie had conceived. Brodie's ingenious procedure was to pass two large curved needles at right angles through the skin and under the tumor, grazing the bone; by traction on the needles the aneurysm was elevated, and a heavy suture was then drawn around the skin beneath the needles. By drawing the suture tight, the tumor was strangulated at the base. This procedure was repeated three days later and again on the fifth day. The mass sloughed away, healed by granulation and did not recur. The accompanying copy (fig. 17) of a drawing from Sir Charles Bell's "Surgical Observations" (1816)[30] shows the use of a tenaculum to elevate a tumor and is similar in principle to Brodie's needles.

The case reported by Warren, of Boston (1867),[17] almost forty years after Brodie's operation, is also noteworthy and the tumor was treated in much the same manner. It was a case of one of the extremely large aneurysms and much like our case 1.

Included in the reports of Heine and Körte (to 1880) are records of 10 cases of extirpation of the aneurysm, with cures; in 6 of these, both common carotid arteries were ligated after intervals of several days, and, curiously, none of the patients died, although there were two deaths following ligations of the common carotid artery. The first

30. Bell, C.: Surgical Observations, London, Longman [and others], 1816.

ligation of the external carotid artery (instead of the common carotid artery) for this purpose was probably performed by Maisoneuve (1851).

At the present time there should be little hazard in the extirpation of these aneurysms because of better hemostasis in the scalp; by the use of the electrocautery, bleeding vessels in the central mass can be coagulated. Despite the great size of the radiating, pulsating vessels, they may be compressed by the fingers on each side of the incision and the ends sealed by turning the galea over them with clamps. The central mass, which is the only part of the aneurysm that needs extirpation, is then isolated and can be quickly excised from the skull, from which the vessels enter, or the mass can be scraped off the skull with a periosteal elevator and the mouths of the bleeding vessels closed with bone wax. After removal of the central mass, the large veins that

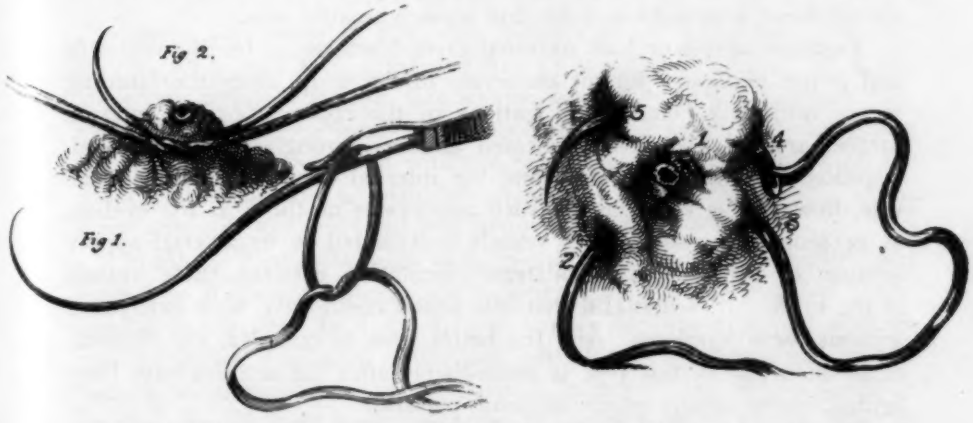

Fig. 17.—Drawings taken from Sir Charles Bell, 1816,[30] showing (*a*) method of elevating vascular mass with the tenaculum and the ligature placed around it and (*b*) method of deep sutures to constrict the vascular area that is bleeding. By these two methods, Benjamin Brodie made a remarkable cure of a large arteriovenous aneurysm of the forehead in 1829. Considering the fact that this was over one hundred years ago, it is a remarkable cure.

are distributed over the scalp collapse and subsequently become inconspicuous.

The type of treatment of these aneurysms depends on whether or not the arterial coil is (1) extracranial or (2) intracranial; if extracranial, removal of the mass will produce a cure; if intracranial, removal of the group of vessels emerging from the skull will cure the extracranial aneurysm, but the primary coils in the dura will continue to cause headache. For the cure of the intracranial angiomatous mass, a semicircular flap of scalp is turned down so as to expose the entire group of vessels emerging from the bone in the involved area. The bone is scraped and waxed, or, as in the other group, when the arterial

supply to the scalp is eliminated the pulsating vessels in the scalp will collapse.

The excision of an angiomatous mass (coil of vessels) that is entirely extracranial (as case 3) is relatively simple. This can be done with (1) a semicircular flap around the angiomatous mass or (2) a straight incision over its center. In either case the mass of vessels is isolated from the scalp and dissected from the skull or scraped from the skull and the entering vessels waxed. Should the tumor invade the skin (as in case 3), a straight incision is preferable because the affected area of skin should be excised. Since the skin is redundant, the edges can be brought together without leaving a defect in the scalp. In 10 of the cases collected from the literature a flap has been used and in 5 a straight incision, at times with a counterincision (Parker, 1904). On the whole, the flap is easier, but if the aneurysm is over the forehead a straight incision will leave a smaller scar.

Ligation of one or both external carotid arteries is hardly advisable and is not necessary for an aneurysm in the scalp, since the bleeding is not difficult to control. Ligations of the common or the internal carotid arteries are never indicated and are strongly contraindicated. Ligation of both the external and the internal carotid arteries on one side, however, is essential for such aneurysms as those in the eyelids, as presented in case 1; both vessels contributed to its arterial supply because of the extensive collateral circulation between these vessels in the orbit. It is doubtful that this lesion could have been extirpated without these ligations. And the better time to complete the removal of an aneurysm of this type is immediately after the arteries have been ligated; delay means return of some pulsation.

If an extracranial aneurysm has been completely removed it probably will not recur. If only partially removed, it will recur unless a fortunate and hardly to be expected progressive thrombosis obliterates the aneurysmal mass.

It is not clear how far one should go in the treatment of the aneurysms with the vascular coils in the dura, from which the aneurysms of the brain and the scalp are supplied. Certainly nothing can be accomplished toward removal of the intracerebral aneurysm; extensive coagulation of the varices of the middle meningeal arteries has been done in these cases, and, I believe, with benefit. Whether or not the extracranial aneurysm would recur unless the dural vessels are also obliterated is not certain, though I should suspect that it might well do so. It seems hardly possible that the headaches would be cured without elimination of the dural vessels. It has seemed advisable to attack the dural vessels in order to increase the probabilities of success. This entails practically no risk, but it does leave a defect in the skull (which, of course, can be corrected later if desired): the skull must

be removed piecemeal, since a bone flap would not be safe with such profuse bleeding. In no other condition is the skull so vascular, not even with dural meningiomas.

It might well appear that the large intracerebral aneurysm would be the source of the headache. This was true in case 7, but many similar arteriovenous aneurysms, without dural connections, have been found at operation and have not caused headache.[31] Moreover, removal of the dural and the extradural vessels does stop the headache in most instances.

It is also difficult to determine whether the aneurysms should be attacked on one or both sides when they are known to be bilateral. My judgment has been to operate on one side only when the headache or noise is unilateral and to operate on both sides when the symptoms are bilateral.

SUMMARY

Seven, and probably 8, of the 9 cases of arteriovenous aneurysm of the scalp and face presented are of congenital origin; in 1 the aneurysm followed trauma late in life, and there was no known preexisting angiomatous lesion. This percentage of congenital aneurysms is approximately in accord with the incidence of such lesions from the cases in the literature. Similar aneurysms in the integument occur elsewhere over the body but less frequently than in the scalp.

In all the 7 cases of aneurysms in the scalp, the arterial supply was traced to the middle meningeal arteries and was therefore of intracranial derivation. In 1 the arterial supply was through two arteries, one on either side, and continuous with the greatly enlarged middle meningeal arteries through the parietal foramens (roentgenologically). In the other 6 there were numerous branches perforating the bone on both sides and derived from great primary plexuses of vessels in the dura (the middle meningeal arteries). In these cases, the roentgenograms disclosed greatly widened grooves of the posterior branches of the middle meningeal arteries, and these were directed to the parietooccipital region, in which the extracranial arteriovenous aneurysms appeared. In 1 case the anterior branch of the middle meningeal was enlarged and supplied a frontal aneurysm of the scalp.

Three of the aneurysms (all with hemianopsia) were demonstrated at operation to be in the brain: one in the frontal and temporal, one in the temporal and parietal and one in the parietal and occipital lobes. In 2 other cases with hemianopsia, the brain was not exposed, but intracerebral aneurysm was doubtless the cause of the hemianopsia.

In 4 cases, there were occasional convulsions, indicating a cerebral lesion, but in 1 of these the convulsions were not due to the aneurysm

31. Dandy, W. E.: Ateriovenous Aneurysms of the Brain, Arch. Surg. **17**:190, 1928.

but to another congenital lesion, i. e., three closely related bony spicules in the sensory leg area. These aneurysms, therefore, may involve the dura and the brain, in addition to the scalp; the arterial supply has been from the middle meningeal artery in all of the cases. Although in all except 1 of our cases the extracranial aneurysms were bilateral, many of the cases assembled from the literature involved only one side of the scalp.

The safest and best treatment of the aneurysms when an extracranial primary angiomatous mass exists is extirpation of the central mass; the large pulsating veins that radiate from the mass disappear when the source of the arterial blood is removed. When the primary angiomatous mass is in the dura, the vessels penetrating the bone should be waxed after the scalp has been stripped from the affected area of bone. It is probably better in these cases to expose and coagulate the dural varices and to ligate one or both (if bilateral) of the middle meningeal arteries.

Many good results have been obtained by injecting sclerosing solutions into the central mass; there may be times when this has an advantage, i. e., when the aneurysm is over the forehead and a scar would be averted or when excision of one in the ear would mean sacrificing part of the ear. Injections are probably more dangerous and are less certain than operation when the latter is performed by a good surgeon; cures from injections are due to thromboses that propagate from the venous into the arterial component of the aneurysm. In the presence of an intracranial aneurysm, sclerosing injections might well be hazardous.

Ligation of the external (not the common) carotid artery is usually not necessary as a preliminary procedure to reduce the arterial content of aneurysms of the scalp. In our case, however, the extirpation of the aneurysm in the eyelids would have been hazardous without ligations of both the internal and the external carotid arteries, both of which contributed to its pulsation because of the extensive anastomoses. Ligations of the arteries in the scalp are useless because they do not supply the aneurysm.

PILONIDAL SINUS AND CYST

A Clinical Study

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THIS clinical study presents a survey of 240 cases of pilonidal sinus and/or cyst encountered at St. Mary's Hospital Group of Hospitals of St. Louis University School of Medicine from the time each hospital of the group was opened (St. Mary's Hospital, 1924 and Firmin Desloge Hospital, 1933) until October 1943. There is a total of 240 cases; 130 at St. Mary's Hospital and 110 at Firmin Desloge Hospital. The cases were studied in detail, and the results are as indicated in this paper.

The literature on the subject contains many papers, especially those dealing with the cause and the treatment of the condition,[1] and a short discussion of the current views on the subject is presented.

From the St. Louis University School of Medicine.

1. Biegeleisen, H. I.: Sclerotherapy for Pilonidal Cyst, Am. J. Surg. **44**: 622-625, 1939. Breidenbach, L., and Wilson, H. L.: Pilonidal Cysts and Sinuses, Ann. Surg. **102**:455-463, 1935. Dunphy, J. E.: The Operative Treatment of Pilonidal Sinus, Surgery **2**:581-584, 1937. Glenn, F.: Pilonidal Sinus, New England J. Med. **207**:544-546, 1932. Hadley, H. G.: Pilonidal Cysts and Sinuses, M. Times, New York **68**:322-323, 1940. Hamby, W. B.: Pilonidal Cyst, Spina Bifida Occulta and Bifid Spinal Cord, Arch. Path. **21**:831-838 (June) 1936. Johnson, W. J., and Levingston, A. G.: The Incidence of Pilonidal Sinuses in Mental Defectives, J. Nerv. & Ment. Dis. **87**:156-158, 1938. Kallet, H. I.: Pilonidal Sinus, Am. J. Surg. **50**:648-652, 1940. Kooistra, H. P.: Pilonidal Sinuses: Review of Literature and Report of 350 Cases, ibid. **55**:3-17, 1942. McKirdie, M.: Pilonidal Sinus, Ann. Surg. **107**:389-399, 1938. Pickett, W. J., and Beatty, A. J.: Pilonidal Cysts in the Army, Am. J. Surg. **56**:375-378, 1942. Rogers, H.: Pilonidal Sinus, Surg., Gynec. & Obst. **57**:803-810, 1933. Sharpe, A. M.: Pilonidal Sinus, Am. J. Roentgenol. **38**:303-307, 1937. Smiley, K. E.: Pilonidal Sinus, Am. J. Surg. **27**:298-301, 1935. Smith, N. D.: Common and Rare Sinuses or Fistulas, Which Occur in the Anus or Near the Anus, S. Clin. North America **19**:1021-1032, 1939. Swinton, N. W., and Hodge, C. C.: The Treatment of Pilonidal Sinus, ibid. **19**:699-708, 1939. Stone, H. B.: The Origin of Pilonidal Sinus, Ann. Surg. **94**:317-320, 1931. Tendler, M. J.: Pilonidal Sinus: Review of the Literature and Report of Eighty-Seven Cases, South. M. J. **34**: 1156-1168, 1941. Weeks, R. B., and Young, G. G.: Sacrococcygeal Cysts, Am. J. Surg. **60**:260-263, 1943. Weinstein, M.: Pilonidal Sinus, Ann. Surg. **97**:80-84, 1933. Whyte, A. H.: Post-Anal So-Called "Pilonidal" Sinus, Proc.

(Footnote continued on next page)

DEFINITION

According to Bacon,[2] a pilonidal sinus is a congenital defect in the midline over the sacrococcygeal region, characterized by the formation of a tract in which are collected the by-products of dermal activity, with a tendency to burrow and undergo abscess formation.

The most generally used, and accepted, name is that of "pilonidal" sinus (or cyst), which means a "nest of hair" (Latin), but not all lesions contain hair. The name is therefore regarded more or less as a misnomer.

Synonyms include such names as pilous cyst; sacral, coccygeal or sacrococcygeal infundibulum; dermoid; dermoid fistula, sinus or cyst; posterior umbilicus; postanal dermoid; congenital dermal sinus; sacrococcygeal ectodermal sinus; sequestration, coccygeal, postsacral traction dermoid, and foveola coccygea.

INCIDENCE

Pilonidal sinus is encountered in both sexes and in all age groups but is most commonly found in young adult males of the pituitary type, tall and obese, with broad hips and hairy bodies.

It is strikingly confined to the Caucasian race, and no reports have mentioned the occurrence of the lesion in the red, the yellow or the brown races. Only a few cases of its occurrence in Negroes have been reported, and Saleeby and McCarthy,[3] who reported 1 such case, stated the belief that the low incidence is due to the negroid pigmentation, which either inhibits the activities of the living cells of the sinus or neutralizes their products by chemical action.

In this series, 163 of 240 patients were men and 77 were women, a ratio of slightly more than 2:1. The average age of the men was 26.2 years and of the women 22.1 years. The oldest patient was 61 years, while the youngest was a newborn infant (2 cases).

ETIOLOGY

The condition is not hereditary, but cases of its occurrence in several members of the same family have been reported. Numerous theories have sought to explain the origin of the lesion, but no one theory is generally agreed on. However, it is generally agreed that the lesion is congenital.

Roy. Soc. Med. **31**:982-984, 1938. Woldenberg, S. C., and Sharpe, W. S.: Surgical Treatment of Pilonidal (Dermoid) Cysts, Surg., Gynec. & Obst. **76**:164-170, 1943. Wolff, J. P.: Pilonidal Cyst, South. M. J. **32**:1243-1245, 1939.

2. Bacon, H. E.: Anus, Rectum, Sigmoid Colon, Philadelphia, J. B. Lippincott Company, 1941.

3. Saleeby, E., and McCarthy, P. A.: Pilonidal Sinus in a Negro, Ann. Surg. **105**:634-635, 1937.

The two prevalent theories as to the causation of pilonidal sinus are (1) that which traces the origin of the condition to a remnant of the neurenteric canal and (2) that which derives the lesion by a process of ectodermal invagination. Investigators who uphold the former theory are in the majority.

The neural theory considers the pilonidal sinus formation as an anlage of development of the neural canal. The ectoderm posterior to the primitive groove thickens and forms two neural folds. These meet in the midline and cone outward posterioly, forming an opening for the neural groove. This groove should close at the end of six months, and when it remains patent such malformations as spina bifida (occulta or externa) result. This entire area is, of course, adjacent and adherent to the bony structure of the body, so that the formation of a sinus tract can readily be understood, as the bony parts grow more rapidly than the skin, and if there is attachment to either the ectodermal rests become stretched into a sinus tract.

As the neural folds coalesce and pinch off from the overlying ectoderm to form the neural cord and canal, ectoderm, and even a well formed sinus tract, may remain behind. This tract may be closed at one or both ends; hence there results a single isolated cyst, a sinus closed at one end or open at either end or, even one communicating with the spinal canal.

Neural buds have been reported in some of the pathologic specimens, and meningitis has been reported as having originated from an infected pilonidal cyst. Spinal fluid has been seen to escape during the excision of a sinus tract.[4]

Gage [5] has studied serial sections of the human fetus and has stated the belief that the true pilonidal sinus and cyst are due to the persistence of the neurenteric canal and are divisible into four groups: (1) sacrococcygeal dimple and sacrococcygeal dimple sinus; (2) true pilonidal sinus, confined to the subcutaneous tissue; (3) true pilonidal sinuses extending into the sacral canal and (4) true pilonidal sinuses which are continuous with the subarachnoid space and canal of the spinal cord.

Studies were also made on the human embryo by Fox,[6] who supported the ectodermal invagination theory and presented evidence which indicates:

1. That pilonidal sinus is a derivative of skin ectoderm and not neurogenic or enteric in origin.

4. Zieman, S. A.: Pilonidal Cysts, Surg., Gynec. & Obst. **66**:231-235, 1938.

5. Gage, M.: Pilonidal Sinus, Arch. Surg. **31**:175-189 (Aug.) 1935; Pilonidal Sinus, Tr. South. S. A. **50**:52-71, 1937; Pilonidal Sinus, Ann. Surg. **109**:291-303, 1939.

6. Fox, S. L.: The Origin of Pilonidal Sinus, Surg., Gynec. & Obst. **60**: 137-149, 1935.

2. That the structures forming the sinus are derived by a process of ectodermal invagination from the skin surface at the time and in the cells destined to form skin appendages (hair and glands) during the third and fourth months of embryonic life.

3. That its mode of origin, and the analogy drawn between this structure and the special "scent" gland in the sacrococcygeal region of birds and amniotes, suggest the probability that the sinus represents a vestigial skin appendage developing at puberty—hence the age distribution of pilonidal sinuses.

4. That coccygeal medullary vestiges exist is not denied, but they do not give rise to the pilonidal sinus. They probably give rise to the large cystic and solid tumors which occur usually in infants and the newly born. There is also the possibility that they may play a rôle in the upward direction which the pilonidal sinus takes.

PATHOLOGY

A pilonidal sinus is usually seen as a very small rounded aperture situated in midline in the skin over the sacrum, the coccyx or the junction of the two. Often a few hairs protrude through the orifice. The tract leads slightly upward through the subcutaneous tissue and ends in a blind pouch or cystic cavity of varying size. Arborization may be produced by epithelial branching. These sinuses may be single, with one external opening, or many external openings may be present. The sinus may extend unilaterally or bilaterally up into the groin or down into the leg. Inwardly, it may communicate with the presacral fascia, extend directly through and into the vertebral canal and even become continuous with the periosteum or the meninges.

Microscopically, the sinus tract is lined with stratified squamous epithelium. The cyst cavity, when present, is lined with the same type of epithelium or with stratified cuboidal epithelium. Sweat glands, hair follicles, hair and occasional neural buds are present. There is a dense chronic inflammatory cell infiltration in and about the sinus or cyst wall, which is surrounded by fibrous tissue and fat. The cyst cavity and the lumen of the sinus tract usually contain debris and pus.

There is no communication with the rectum, nor is any endodermal tissue found.

Malignant changes in a pilonidal sinus or cyst have not been reported in the literature to date.

In 217 of the cases under discussion, tissue was removed for gross and microscopic examination. Of the lesions, 111 were described as being sinuses and 106 as being definitely cystic, i. e., having a demonstrable cavity though no definite epithelial lining was described. Hair was present in 10 of the sinus specimens and in 44 of the cystic specimens, making a total of 54. Therefore, 25 per cent of the 217 specimens contained gross or microscopic evidence of hair. Though

epithelial elements were described in almost every case, no mention was made of any nerve tissue being present.

SYMPTOMS

The lesion is without symptoms until infection has taken place. Trauma is almost invariably the inciting factor. However, falling and striking the coccygeal region, long and frequent automobile rides, horseback riding and direct violence (often in the course of some sport) are most frequently cited as preceding the onset of the symptoms. It has been referred to as the "jeep disease" by Buie [7] in a recent article, because of the frequency of the lesion in the military service.

Following trauma, infection takes place, usually with a Staphylococcus, though Bacillus coli is not an infrequent contaminator. The infection results in a chronic discharge, with pain and tenderness in the part. Abscesses often form, and these require drainage. The discharge consists of sebaceous material, epithelial debris and pus, which sometimes irritates and causes a pruritus.

At times, a dull ache is present in the lower part of the back, but constitutional symptoms are rare.

Pain and discharge were the two commonest symptoms encountered in this series of cases, and the average duration of the symptoms was 2.6 years. Pain was present in 133 cases, discharge in 198 cases and both pain and discharge in 102 cases.

DIAGNOSIS

The diagnosis is made on the history of the case and the presence of one or more small sinus openings, usually located in the midline over the sacrococcygeal region. A small tuft of hair frequently protrudes from the orifice of the sinus. The skin about the sinus opening is usually reddened, and a thin seropurulent discharge exudes from the orifice. A probe is readily passed into the sinus tract, usually in an upward direction.

A roentgenographic examination of the sinus following injection of an opaque substance has been advocated, usually as a preoperative procedure, to determine the extent and direction of the sinus tract or tracts. In only 1 case in this series was this procedure used.

In 159 cases in the series, one sinus tract was present; in 35 cases two sinus tracts were present; in 13 cases three sinus tracts were present, and in 17 cases more than three tracts were present. Thus in 224 of 240 cases there were sinus tracts. A scar is described as having been present in 5 cases, and no mention is made of any sinus (or scar) in 11 cases.

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7. Buie, L. A.: Jeep Disease (Pilonidal Disease of Mechanized Warfare), South. M. J. **37**:103-109, 1944.

DIFFERENTIAL DIAGNOSIS

Pilonidal sinus is to be differentiated from other conditions that occur about the sacrococcygeal region, such as tuberculosis, syphilis, osteomyelitis of the coccyx or sacrum, anal or rectal fistulas, sebaceous cysts, pyogenic infections, presacral dermoids, ischiorectal abscesses, carbuncle of the buttocks, lipomas, teratomas, fetal implantations, traumatic dermoids, implantation cysts, anthrax and actinomycosis.

TREATMENT

The treatment of pilonidal sinus has received much attention because of the long period of healing required by some methods and because of the frequency of recurrence of the lesion. Many forms of treatment are advocated, but radical excision gives the greatest percentage of permanent cures.

Conservative treatment includes hot sitz baths; cauterization of the sinus tract with phenol, silver nitrate, nitric acid or other caustic agents; simple incision with packing of the cavity with iodoform gauze, or repeated swabbing with tincture of iodine. All these methods give considerable relief of symptoms for periods of days and sometimes months.

Cutler and Zollinger suggested a modification of Carnay's solution as a sclerosing solution; this consists of absolute alcohol, 6 cc.; chloroform, 3 cc.; glacial acetic acid, 1 cc., and ferric chloride, 1 Gm. They reported good results from use of this solution.

Rogers and Hall [8] recommended repeated excisions with cauterization of the diseased tissue only, carried out as minor operations on ambulatory patients.

Block and Greene [9] have treated a small group of patients by means of simple incision and application of a sclerosing solution, and results were good.

Turell [10] advocated radiation therapy as a substitute for operation for the recurrence of infected sacrococcygeal sinus, and Smith [11] stated the belief that roentgen radiation given preoperatively and postoperatively is a definite adjunct in the treatment of pilonidal sinus.

That radical elliptic excision of all the diseased tissue down to the fascia covering the sacrum is the method of choice is rather generally

8. Rogers, H., and Hall, M. G.: Pilonidal Sinus, Arch. Surg. **31**:742-766 (Nov.) 1935.

9. Block, L. H., and Greene, B. L.: Pilonidal Sinus: Sclerosing Method of Treatment, Arch. Surg. **37**:112-122 (July) 1938.

10. Turell, R.: Radiation Therapy for Recurrent Sacrococcygeal Cysts and Sinuses, Surgery **8**:469-472, 1940.

11. Smith, R. M.: Roentgen Irradiation as Adjunct to Surgical Treatment of Pilonidal Cyst, Am. J. Roentgenol. **38**:308-311, 1937.

agreed on, but the method of treating the wound varies, as is indicated in the following paragraphs.

Various dyes, especially methylthionine chloride and gentian violet medicinal, are sometimes injected into the sinus tract prior to excision as an aid in identification of the diseased tissue. This was done in many of the cases in this series, but it is not a necessary procedure, because it is usually not difficult to differentiate between normal and abnormal tissue and, again, the dye often infiltrates and stains the tissue surrounding the sinus or cyst wall.

Weeder [12] advocated excision of the coccyx in cases in which roentgenologic examination of a sinus tract injected with iodized poppyseed oil or other substance opaque to roentgen rays shows the tract to invade the sacrococcygeal joint; in cases in which after a careful injection with methylthionine chloride a discoloration at the sacrococcygeal joint is shown, and in cases in which the chacracter of the tissue about the sacrococcygeal joint is under suspicion. He argued that a remnant of the cyst wall is contained within the sacrococcygeal joint as an unobliterated portion of the medullary canal.

No palliative measures were employed in the treatment of any of the patients while in the hospital. Patients not treated, including 2 newborn infants, were in the hospital for treatment of some other condition. Incision and drainage was done for those patients with associated acute abscess.

The various methods of treatment used in this series of cases are as follows: (1) excision, wound left open with gauze pack; (2) excision, closure with secondary sutures; (3) excision, partial primary closure with pack; (4) excision, primary closure with drain; (5) excision, complete primary closure; (6) excision, pedicle flap method with primary central closure; (7) excision, with lateral incision and double primary closure; (8) marsupialization; (9) opening, curettement and packing of the lesion, (10) incision and drainage.

The table indicates the number of patients treated with each method, the number followed and the number cured.

Several anesthetics were employed. The various types and the number of cases in which each was used are shown in table 2. In 9 cases, the type of anesthetic was not indicated.

An attempt was made to follow up each patient, but, owing to change of address, change of name or other circumstances, a large percentage of patients could not be properly followed. The few exceptions previously mentioned include the patients who did not undergo radical treatment for the condition and so were not followed. To the

12. Weeder, S. D.: Pilonidal Cyst: Its Etiology and Treatment, Ann. Surg. **98**:385-393, 1933.

patients who did not return to the hospital for further treatment of a recurrence, a questionnaire was mailed. This was returned by the patient, with answers to questions as to any further local pain, swelling or discharge following operation and discharge from the physician's care. Needless to say, not all questionnaires were returned. In many

TABLE 1.—*Types of Treatment for Patients with Pilonidal Sinus and Cyst, with Number of Operations and Number Cured*

Type of Operation	Number of Patients	Patients Followed	Cured with 1 Operation		Cured with 2 Operations		Cured with 3 Operations		Total Cured	
			No.	%	No.	%	No.	%	No.	%
Excision; wound open with pack	106	65	47	72	6	9.2	1	1.5	54	86
Excision; closure with secondary suture	2	1	1	100	..	..	..	..	1	100
Excision; partial primary closure with pack	6	6	5	83	1	17	..	..	6	100
Excision; primary closure with drain	36	22	13	59	2	9	..	..	15	68
Excision; complete primary closure	65	43	30	70	4	9	..	..	34	79
Excision; closure with pedicle flap	2	2	0	0	2	100	..	..	2	100
Excision; lateral incision and closure	3	3	3	100	..	..	..	..	3	100
Marsupialization	1	1	1	100	..	..	..	..	1	100
Lesion opened, curetted, packed	2	1	1	100	..	..	..	..	1	100
Incision and drainage	8	0	0	0	..	..	..	..	0	0
Not treated	9	0	0	0	..	..	..	..	0	0
All types (totals)	240	144	101	70	15	10	1	0.7	117	81
Corrected for incision and drainage and not treated	223	144	101	70	15	10	1	0.7	117	81

TABLE 2.—*Types of Anesthetics Used*

Anesthetic	Number of Cases
Spinal	113
Gas (nitrous oxide, ethylene or cyclopropane)	66
Ether	11
Gas and ether	2
Local (procaine hydrochloride infiltration)	19
Evipal sodium	1
Total	212

cases, therefore, the criteria of a recurrence of the lesion once it had been excised lay in the patient's interpretation of and answers to these questions.

Gage [5] stated that recurrence of the condition is due to one or more of the following causes: (*a*) Presence of infection in both primary sinuses and primary cysts, as well as in secondary sinuses; (*b*) failure to obliterate dead space at the time of primary suture of the wound, and

(*c*) failure of complete removal of the epithelium-lined pilonidal sinus and accessory sinus tracts.

A total of 34 patients had acutely inflamed pilonidal sinuses. In 1 case the lesion was opened, curetted and packed with gauze. In 8 cases of abscess, incision and drainage were done. In the remaining 25 cases, the lesion was excised and predominantly acute inflammatory reaction was observed on microscopic examination of the removed tissue. Of these 25 cases, there were recurrences in only 3; thus 88 per cent of the patients in these cases were cured. It would seem from this that infection (the most common cause of acute inflammation in a pilonidal lesion) had but little to do with recurrences in this particular series of cases.

CONCLUSIONS

1. Radical excision of all the diseased tissue down to the fascia covering the sacrum is the method of choice in the treatment of pilonidal sinus and/or cyst.

2. The lesion is prone to recur, as is evidenced by the fact that in only 70 per cent of the cases followed was cure effected by one operation.

3. By far the great majority of patients are cured by two operations (only 1 patient required three operations).

4. A total of 81 per cent of patients were cured by use of various methods of treating the defect resulting from excision of the lesion.

5. The most effective type of operation, and the one most frequently used, was that of leaving the wound open for granulation.

6. Of the patients with associated acute inflammation, 88 per cent were cured. Acute inflammation, therefore, does not influence the ratio of recurrence.

EFFECT OF INTRAVENOUS ADMINISTRATION OF OXYGEN ON SHOCK IN DOGS AND IN HUMAN BEINGS

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THAT anoxemia is an important factor in the pathogenesis of traumatic shock has long been recognized.[1] Experimental[2] and clinical[3] investigations have yielded encouraging results in combating such shock by the inhalation of high concentrations (100 per cent commercial) of oxygen. Boothby and his collaborators[3] expressed the opinion that the use of such high concentrations of oxygen resulted in a significantly greater degree of recovery than when the usual 95 per cent oxygen and 5 per cent carbon dioxide inhalant mixture was employed. The additional 5 per cent oxygen yielded an increase of 2.2 cc. of oxygen per hundred cubic centimeters of blood. Small though the increase be it causes a rise in oxygen saturation of capillary and venous blood in cases of shock from 20 per cent saturation to 33 per cent

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† Dr. Jennings, chief surgeon of the Beth-El Hospital, died on May 25, 1945.

1. Moon, V. H.: Shock and Related Capillary Phenomena, New York, Oxford University Press, 1938, pp. 167-172 and 361-370. Blalock, A.: Principles of Surgical Care: Shock and Other Problems, St. Louis, C. V. Mosby Company, 1940, pp. 129, 132, 137 and 141.

2. Wood, G. O.; Mason, M. F., and Blalock, A.: Studies on Effects of Inhalation of High Concentrations of Oxygen in Experimental Shock, Surgery **8**:247, 1940. Schnedorf, J. G., and Orr, T. C.: (*a*) Beneficial Effects of Oxygen Therapy in Experimental Traumatic Shock, Surg., Gynec. & Obst. **73**:79, 1941; (*b*) Beneficial Action of Oxygen Therapy in Experimental Shock, ibid. **73**:301, 1941; (*c*) Oxygen Therapy in Shock Due to Hemorrhage, ibid. **73**:495, 1941.

3. Boothby, W. M.; Mayo, C. W., and Lovelace, W. R.: One Hundred Per-cent Oxygen: Indication for Its Use and Methods of Its Administration, J. A. M. A. **113**:477 (Aug. 5) 1939.

saturation. The oxygen partial pressure rises from 14 to 21 mm., with an equivalent rise of 50 per cent of oxygen pressure in the tissues. The net result is a striking increase in oxygen available to the tissues.[3]

Several attempts have been made in the past to administer gaseous oxygen intravenously.[4] All were discontinued because of the development of such undesirable effects as embolism or cardiac tamponade. An analysis of these attempts shows that the amounts of oxygen administered were too large or that the gas was injected too rapidly or at too high a pressure. Despite the fact that physiologists had long administered gaseous oxygen intravenously to animals without harm,[5] so ingrained has been the clinician's fear of air embolism that attempts at using oxygen intravenously were regarded as curios and dropped after brief and generally incomplete study. That air embolism is not so common as a review of medical texts would lead one to believe is evidenced by the records of the Office of the Chief Medical Examiner of the city of New York. Thus, in over 150,000 autopsies in cases of a wide variety of diseases with conditions favorable to the development of air embolism, only 20 cases of this condition are recorded.[6] All occurred when air—not oxygen—was forcibly and rapidly injected into hollow viscera (tubal insufflation, aerograms of the bladder in cases of ulcerated carcinoma and other methods) and rapidly entered the circulation. Of the untold numbers of intermittent and continuous procedures in intravenous administration in daily medical use, air embolism is apparently so rare a complication as to be recorded in isolated case reports.[7]

It must further be emphasized that air and oxygen are not at all comparable from the standpoint of intravenous administration. Atmospheric air contains 20.94 volumes per cent of oxygen, 0.04 volume per cent of carbon dioxide and 79.02 volumes per cent of nitrogen

4. Mariani, F.: Le iniezioni endovenes di ossigeno nell' uomo, Riforma med. **18**:194, 1902. Tunnicliffe, F. W., and Stebbing, G. F.: The Intravenous Injection of Oxygen as a Therapeutic Measure, Lancet **2**:321, 1916. Singh, I., and Shah, M. J.: Intravenous Injection of Oxygen, ibid. **1**:922, 1940.

5. Nysten, P. H.: Recherches de physiologie et de chimie pathologiques, Paris, J. A. Brosson, 1811; cited by Demarquay, J. N.: Essay on Medical Pneumatology: Physiological, Clinical and Therapeutic Investigation of the Gases, translated by S. W. Wallian, Philadelphia, F. A. Davis Company, 1889, pp. 75-82. Gaertner, G.: Ueber intravenöse Sauerstoffinfusionen, Wien. klin. Wchnschr. **15**:691, 1902. Stuertz, E.: Ueber intravenöse Sauerstoffinfusionen, Ztschr. f. diätet. u. physik. Therap. **7**:67, 1904. Bourne, G., and Smith, R. G.: The Value of Intravenous and Intraperitoneal Administration of Oxygen, Am. J. Physiol. **82**:328, 1927. Dick, M.: The Respiratory and Circulatory Responses to Intravenous Oxygen and Their Relation to Anoxemia, Am. J. Physiol. **127**:228, 1939.

6. Gonzales, T. A.: Personal communication to the authors.

7. Terplan, K., and Javert, C. T.: Air-Embolism Following Intravenous Drip, Am. J. Path. **11**:880, 1935.

(including 0.94 volume per cent of argon and other rare gases).[8] Thus its greatest components are irrespirable gases. In perfectly normal respiration, from 4 to 6 per cent of the inspired atmospheric oxygen is utilized.[8] Oxygen, per contra, is entirely respirable. If given intravenously, at a slow rate and at pressures not substantially greater than venous pressure, it should exert far more potent physiologic effects than when inhaled and in comparatively minute quantities.

Ziegler[9] in 1941 described an apparatus for administering pure oxygen intravenously at low pressures and in physiologic amounts and mentioned its use by this route for several patients. He noted no deleterious effects but gave no details of the results. Using Ziegler's apparatus with minor modifications, we have studied the effects of intravenously administered 100 per cent (commercial and U. S. P.) oxygen in animals with experimentally induced toxic shock and in 3 human beings with severe acute progressive (secondary traumatic) shock.[10]

EXPERIMENTAL STUDIES

In 12 dogs a shocklike state, to complete coma, was produced by the intravenous injection of a saline extract of dog muscle as suggested by Moon.[11] The dose given

Effect of Intravenous Administration of Plasma and Oxygen on Experimental Shock in Dogs.

Dog	Weight, Kg.	Dose Muscle Extract, Gm.	Initial Blood Count, Million R.B.C./Cu. Mm., Average, 4 Days	Blood Count Beginning Treatment, Million R.B.C./Cu. Mm.	Hemoconcentration, %	Treatment	Final Blood Count, Million R.B.C./Cu. Mm.	Result
1	11.4	80	5.1	7.7	50	None	8.5	Death, 7 hr.
2	11.2	80	5.0	7.6	52	None	8.1	Death, 7 hr.
3	11.0	78	4.8	7.7	60	None	8.0	Death, 5 hr.
4	11.4	80	5.0	7.2*	44	300 cc. plasma	7.8	Death, 10 hr.
5	11.6	81	5.3	7.8*	47	500 cc. plasma	8.1	Death, 11 hr.
6	11.5	80	5.1	7.5*	47	400 cc. plasma	8.6	Death, 11 hr.
7	11.4	80	5.0	7.6*	52	400 cc. oxygen	6.5	Death, 17 hr.
8	11.5	80	5.0	7.7*	54	2,100 cc. oxygen	5.4†	Recovery
9	11.0	78	5.0	7.9*	58	1,800 cc. oxygen	5.2†	Recovery
10	11.1	80	5.0	7.6*	52	2,800 cc. oxygen	5.4†	Recovery
11	11.0	80	4.8	8.0*	66	2,700 cc. oxygen	5.2†	Recovery
12	11.3	82	5.2	8.9*	70	2,500 cc. oxygen	5.0†	Recovery

* Count not lower than 40 per cent concentration for four hours before treatment was begun.

† Count not higher than this level for four hours before oxygen was discontinued.

8. Best, C. H., and Taylor, N. B.: The Physiological Basis of Medical Practice, ed. 2, Baltimore, Williams & Wilkins Company, 1940, p. 511.

9. Ziegler, E. E.: The Intravenous Injection of Oxygen J. Lab. & Clin. Med. **27**:223, 1941.

10. Richards, D. W., Jr.: The Circulation in Traumatic Shock in Man, Bull. New York Acad. Med. **20**:363, 1944.

11. Moon,[1] p. 189.

was the extract equivalent of 7 Gm. of muscle per kilogram of body weight, a dose previously shown by Moon and confirmed by our experience to induce an irreversible shocklike state and death of the animal. When the hemoconcentration had remained at or above the critical level of 40 to 50 per cent for at least four hours, 3 dogs were given 300 to 500 cc. of dog plasma intravenously and 5 were given 100 per cent (medicinal) oxygen intravenously continuously for between ten and fourteen hours at the rate of 100 cc. per hour—i.e., until the capillary blood count had returned to the level existing before the muscle extract was administered—and had remained at this level for four hours. Early in the experiment, 1 such dog received oxygen intravenously for three hours, with a drop in hemoconcentration to 30 per cent, at which time the oxygen was discontinued. This dog subsequently had a relapse and died. Three dogs in a deep shocklike state were not treated. The results are summarized in the table.

The untreated and the plasma-treated dogs and the 1 incompletely treated with intravenous administration of oxygen all died, the last surviving six hours longer than those of the other two groups. At autopsy, well marked parenchymal congestion and hemorrhages, extremely viscid venous blood and poorly filled vessels were found, conditions similar to those found by Moon.[12] The 5 dogs receiving oxygen intravenously for long periods survived and were well until killed between the third and the twenty-first day after the experiment, at which time the only evidence of the antecedent shocklike state was the presence of fading parenchymal, chiefly colonic mucosal, hemorrhages of increasing age and diminishing extent. No evidence of air embolism or tamponade was noted clinically or at autopsy in any dog.

REPORT OF CASES

CASE 1.—J. G., a 60 year old white man, was admitted to Beth-El Hospital on July 10, 1942, with a history of progressive loss of weight, anorexia and vomiting of six months' duration. He was extremely cachectic, weighing 85 pounds (38.6 Kg.). His abdomen was scaphoid, and tenderness was present in the right upper quadrant and epigastrium; no masses were palpable. Roentgen ray examination showed an annular canalization of the midportion of the stomach, involving the major part of the pars media, with a wide contracture of the greater curvature; there was a residue of 90 per cent of the ingested barium sulfate after six hours, with a few specks of barium in the ileum. His red cell count was 2,800,000 per cubic millimeter, and his hemoglobin content was 50 per cent (Sahli). Despite three blood transfusions (2,000 cc.), the red cell count rose only to 3,100,000 and the hemoglobin content to 53 per cent. His preoperative blood pressure was 108 mm. of mercury systolic and 64 mm. diastolic. Though he was considered a poor operative risk and the carcinoma was deemed far advanced and probably inoperable, the patient insisted on operation, stipulating further that every attempt be made at resection of the tumor.

With the patient under fractional spinal procaine hydrochloride anesthesia, a difficult subtotal gastrectomy was performed on July 20. The stomach was adherent to the colon, small intestines and liver, but there was no apparent neoplastic involvement of these viscera.

One hour after the operation was begun (at which time he had received 75 mg. of procaine hydrochloride), considerable thirst developed. His skin became moist and cold and his color pallid. He retched and vomited several times. At first restless, he became progressively apathetic and then lapsed into coma. His blood pressure, which, with continuous transfusion from the start of the operation, had initially

12. Moon,[1] chap. 13, pp. 188-213.

fallen to 80 mm. of mercury systolic and 60 mm. diastolic and returned to 104 mm. systolic and 70 mm. diastolic, now began to fall progressively, despite the continuing transfusion and the administration of epinephrine, nikethamide and caffeine and sodium benzoate and of oxygen by inhalation. One and three-quarters hours from the beginning of the operation he was pulseless, his blood pressure was unobtainable and his lungs were full of coarse rales. His heart sounds were extremely feeble and exceedingly rapid. A small amount of extremely viscid blood exuded from veins as they were severed, the surgeon commenting that the vessels were "empty." The lips and face were chalky white and bloodless. The cell volume by hematocrit reading at this time was 72 per cent. The specific gravity of the capillary blood was 1.0704 (normal 1.0566).

At this point all other medication and the transfusion were discontinued and intravenous administration of 100 per cent oxygen was started at a rate of 600 cc. per hour. After the oxygen had been flowing for eleven minutes, the blood became bright pink and fluid; it flowed in considerable amounts as veins were severed. The surgeon, in fact, was greatly surprised at the fulness of the veins. Fifteen minutes after the intravenous administration of oxygen had been begun, the patient regained consciousness. His blood pressure at this time had risen to 98 mm. of mercury systolic and 62 mm. diastolic, the pulse rate was 88 per minute, the pulse was of good quality and regular and the heart sounds were distinctly audible and of good quality. His lungs now showed only a few rales, and even these had disappeared within a few more minutes. The cell volume by hematocrit reading had diminished to 61 per cent. The specific gravity of the capillary blood had fallen to 1.0640. Despite the further administration of 100 mg. of procaine hydrochloride in four divided doses intraspinally during the succeeding ninety minutes that the operation consumed and despite considerable manipulation necessitated by the separation of the adhesions, the patient's color, venous filling, alertness and blood pressure remained unchanged. The oxygen was continued intravenously throughout the remainder of the operation; no other adjuvant therapy was employed. The cell volume by hematocrit reading had further diminished to 56 per cent, and the specific gravity of the capillary blood had further fallen to 1.0593.

When the patient had been returned to the ward after three and one-half hours in the operating room, the intravenous administration of oxygen was again started at the rate of 600 cc. per hour and at a pressure just sufficient to clear the glass viewing adapter proximal to the intravenous needle of the blood that had refluxed into it as the needle was inserted into his vein. At this rate and pressure it was continuously administered for the ensuing thirty hours, during which period the patient received 18,000 cc. of oxygen. His pulse rate was constantly maintained at 80 per minute, and the pulse was full and regular. The patient's respiratory rate was maintained at 20 per minute and was regular. His lungs were clear throughout. The heart sounds were of good quality. The blood pressure rose to 106 mm. of mercury systolic and 74 mm. diastolic within two hours after the administration of oxygen was begun and remained at this level. The patient was mentally so alert that he realized that some unusual procedure was being attempted, from the number of observers who visited him during this period, and he commented on the fact. After thirty hours of intravenous injections of oxygen, cell volume by hematocrit reading was 37 per cent and specific gravity of the capillary blood 1.0549. On the day after the intravenous administration of oxygen was discontinued, one hypodermoclysis of 2,000 cc. of 5 per cent dextrose in isotonic solution of sodium chloride and one 500 cc. transfusion of whole blood were given. The patient was taking fluids by mouth on the third postoperative day and food on the fourth, and he left the hospital, free of symptoms, on the twelfth day after operation.

CASE 2.—C., a newborn boy, was delivered by podalic version on July 3, 1944. He sustained fractures of the right clavicle and both humeri and probable fractures of the skull and the spine during the delivery. The child was semicomatose and did not respond to any stimulation, and both lower and upper extremities were flaccid. No cry or sucking reflex was present. He was intensely cyanotic. Respiratory movements were shallow, of the abdominal type, extremely irregular and about 36 per minute. No breath sounds were heard; heart sounds were rapid and feeble. These conditions became progressively more pronounced for three days, despite transfusions (100 cc. of Rh-negative compatible blood), cardiac stimulants and oxygen by nasal catheter. On the third day, the child appeared to be dying. There was pronounced edema of the thighs.

At this point, all supportive measures, including transfusions, were discontinued. Intravenous administration of 100 per cent oxygen was begun at the rate of 90 cc. per hour and was continued without interruption for fourteen hours. Cyanosis completely disappeared within four minutes after the intravenous administration of oxygen was started. The respiratory rate dropped to 14 per minute within half an hour after the oxygen was started, its rhythm becoming regular. A strong cry and sucking reflex became manifest in eighty minutes; after the oxygen had been flowing for six hours, the lungs showed signs of expansion, and breath sounds were heard throughout the chest after eight hours of oxygen therapy. After twelve hours, the child having received 1,080 cc. of oxygen intravenously, the edema of the thighs had totally disappeared. The child lived for three weeks after the oxygen was discontinued, without further therapy, taking its feedings well, breathing regularly and rhythmically and showing no further evidences of anoxemia or shock. During the third week, a complicating pneumococcic meningitis developed. Because of the paraplegia of the lower extremities and the severe injury to the cord, no attempt to treat the meningitis was made. At autopsy, fractures of the skull, the sixth cervical vertebra, the right clavicle and both humeri were found. There was a large organized subdural hemorrhage over the superior cerebral surfaces and numerous fading subpial ecchymoses. The cervical portion of the spinal cord was lacerated in the region of the vertebral fracture. There were gross (kernicterus and hepatosplenomegaly) and microscopic evidences of erythroblastosis. There were no residual changes suggesting that at any time during the life of the child had air embolism occurred. Numerous sections of the heart, the brain and the lungs failed to show any evidence of vascular rupture or perivascular hemorrhages such as have been described in cases of air embolism,[13] and there was neither gross nor microscopic evidence of infraction in any organ.

CASE 3.—B., a white male infant, was delivered on Jan. 10, 1945 by midforceps at term, weighing 9 pounds 3 ounces (4,170 Gm.). Resuscitation was difficult, requiring the use of a resuscitator for one hour and the injection of nikethamide and alpha lobeline into the cord. When breathing finally was begun, the respirations were irregular, extremely rapid (about 100 per minute) and shallow. The infant was extremely cyanosed. The extremities were toneless and limp. Tremors of the lips were noted. Heart sounds were of fair quality. No breath sounds could be heard on auscultation. The rectal temperature was 97 F. The child appeared to be in collapse. Intracranial hemorrhage was suspected.

13. Gonzales, T. H.; Vance, M., and Helpern, M.: Legal Medicine and Toxicology, New York, D. Appleton-Century Company, Inc., 1937, pp. 99 and 100. Weitzman, C. C., and Cohen, M.: Rubin Test with Fatality, New York State J. Med. **37**:1582, 1937.

The infant was placed in an oxygen tent. Five-tenths cubic centimeter of a preparation of vitamin K was given intramuscularly. The trachea was aspirated and found patent. Hot water bags and blankets were applied to the body and extremities. After three hours of this regimen, the infant appeared to be dying.

The child was then taken from the oxygen tent and, with external heat still applied, intravenous administration of oxygen was begun at the rate of 200 cc. per hour. The oxygen was continuously administered intravenously for the ensuing thirty-six hours, with three brief interruptions, of about twenty minutes each, necessitated by clotting within the needle. In all, the child received 7,000 cc. of oxygen intravenously. Eight hours after the intravenous administration of oxygen had been begun, 100 cc. of 5 per cent dextrose solution was given intravenously.

Cyanosis was lessened within a few minutes after the intravenous administration of oxygen was begun. In fifteen minutes, the child had become pink and remained so except during the periods when the oxygen was discontinued, relapsing rapidly into a state of deep cyanosis during these intervals. The respiratory rate slowly but progressively diminished, becoming 30 per minute and being regular and deeper in eight hours after the beginning of the intravenous injections of oxygen. The rectal temperature four hours after institution of intravenous injections of oxygen was 98 F. After eleven hours the rectal temperature was 99.2 F.; after eighteen hours it was 100 F. and remained at this level. The body of the infant had become warm by the time the intravenous injections of oxygen had been administered for ten hours. External heat was, however, continued for four hours longer, no external heat being supplied thereafter.

The infant began to manifest generalized convulsions six hours after delivery. These became more frequent and of longer duration. The child died on the third day after delivery. At autopsy, a large subdural hematoma and multiple subpial cortical ecchymoses were found. The left occipital bone showed a long transverse fissure fracture. The other organs showed severe congestion. The lungs showed a widespread patchy atelectasis. No evidence of intravascular or intracardiac gaseous contents was discernible. There was no evidence of cardiac tamponade nor any suggestion of embolization in any organ. Microscopic examination failed to show any signs of vascular laceration or of infarction in any organ.

SUMMARY AND CONCLUSIONS

Gaseous oxygen was administered intravenously to 12 dogs in which irreversible toxic shock had been produced experimentally and to 3 human beings with severe traumatic secondary shock. No symptoms of vapor lock (cardiac tamponade), gas embolization or other deleterious effect developed clinically, and no evidence of embolization or vapor lock was noted at autopsy in the animals.

Five of the 6 dogs treated with intravenous administration of oxygen completely recovered from the state of shock, their hemoconcentration falling from a level of 52 per cent to one of 70 per cent before treatment to preshock levels after treatment.

All 3 human beings recovered rapidly from the clinical and laboratory evidences of shock. The first clinical manifestations of improvement occurred in a matter of a few minutes after the intravenous administration of oxygen was begun. The earliest evidences of this improvement consisted in the return of normal color to mucous mem-

branes and an increasing bright pink-red color to the blood, followed by an elevation in blood pressure and diminution in respiratory rate. The concentration of blood cells and the specific gravity of the capillary blood, both previously extremely elevated (1 case), fell rapidly toward normal.

Gaseous oxygen, intravenously administered at pressures at or slightly above venous pressure and at rates of 60 to 600 cc. per hour. depending on the size and the age of the person, can be given with safety and may be of value in the treatment of secondary shock. So administered, it may be efficacious when oxygen by inhalation fails to yield therapeutic effects, since by the intravenous route a lung functionally deficient because of the frequently present edema or other mechanism leading to faulty pulmonary aeration can be by-passed and the necessary oxygen made available to the body.

With the present status of available apparatus for administering gaseous oxygen intravenously, constant attention to the machine is imperative. Frequent regulation of the rate of flow and the pressure as the dynamics of circulation are altered under therapy are necessary. Experiments are presently under way to construct an apparatus that will automatically compensate for these and other variables and will eliminate the constant attention presently required.

STUDY OF GASTRIC LESIONS BY MEANS OF BIOPSY SPECIMENS REMOVED ENDOSCOPICALLY

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WHILE gastroscopy is one of the oldest methods of examination of the stomach, its limitations were so great that it was of little clinical help until the advent of the flexible gastroscope, with the pioneering work of Schindler. In the hands of one skilled in the use of such an instrument, gastroscopic examination now has become an important addition to the armamentarium of the gastroenterologist and of every one interested in gastric lesions.

In spite of its proved value, however, gastroscopy still possesses two definite defects. One is that a small but sometimes important area of the stomach cannot be visualized by the gastroscope, and the other is that diagnosis is almost completely established by topographic observation only. For many fairly well advanced lesions, such topographic observation is adequate to establish a diagnosis; as a matter of fact, in many such cases gastroscopic examination is hardly necessary for an understanding of the true nature of the disease. In the case of a small borderline lesion, visualization alone may be inadequate.

In the differentiation between early gastric cancer and benign ulcer, error in gastroscopic diagnosis is often encountered. To the surgeon, who has become more accustomed than the internist to the difficulty of differential diagnosis when confronted with such a small questionable lesion in the stomach at operation, this occasions no great surprise. He is familiar with many instances in which not only inspection leaves much to be desired but also palpation does not give the necessary information and a frozen section must be relied on. Because of the inability of gastroscopic observation alone to offer the greatest amount of help where it is needed, namely, in the early or the atypical case, the surgeon has probably taken to this method of examination somewhat less enthusiastically than have his colleagues in internal medicine.

It will be recalled that the cystoscope became much more valuable to the urologist when it became possible to remove a small portion

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of tissue from the bladder endoscopically for microscopic study. It will also be recalled that when a biopsy forceps was designed to be used with the bronchoscope the study of thoracic lesions and thoracic disease underwent an almost revolutionary change. By means of these instruments the removal of a small portion of tissue under direct visualization with subsequent microscopic study has changed the accuracy of diagnosis from one of opinion based on quick and incomplete observation to one of more careful study by use of the microscope. Because of the obvious value of such a method of study in examination of the stomach, one of us (B. K.) set about to construct such an instrument to be used in conjunction with the gastroscope. This was done with the help of the Phillips-Drucker Company, of St. Louis, and it has been recently described.[1] The present report is a preliminary appraisal of the value of the study by biopsy of the stomach mucosa removed through the gastroscope by such a forceps.

Fig. 1.—Artist's drawing of view through gastroscope as the forceps removes a bit of tissue for biopsy. The case is one of atrophic gastritis.

A description of the instrument together with our technic of operation was presented in a previous publication. Briefly, the instrument is a flexible steel cable of fine caliber which can be attached externally to the gastroscope, thereby increasing by only 3 mm. the diameter of the latter. The cutting head is abducted from the objective within the stomach and a small section of tissue excavated under visual control. This is regulated by manipulation of the proximal screw and lever apparatus adjacent to the gastroscopic ocular. After the tissue has been removed, the forceps head is rapidly adducted and the combined instruments are withdrawn (fig. 1).

In no case so far has hemorrhage at the site of biopsy been alarming. Minor bleeding is always present. Indeed if this does not occur, it is

1. Kenamore, B.: A Biopsy Forceps for the Flexible Gastroscope, Am. J. Digest Dis. **7**:539 (Dec.) 1940.

felt that the biopsy specimen is of insufficient depth to be of diagnostic value. In many sections taken, strands of muscularis mucosae have been present.

In all, thirty-five biopsies have been obtained, and in no instance has any patient manifested untoward reactions. True, not in all cases in which biopsy has been attempted could tissue be removed, nor in every case could a particular area under suspicion be reached by the forceps. Such failures constitute a small percentage of the total number of attempts, however, and we think that they will detract but little from the ultimate value of the instrument.

Just as there are certain blind spots in ordinary gastroscopic examination, so are there in gastroscopic biopsy regions of the gastric mucosa which are inaccessible to the forceps. The most important of these is the antrum. The forceps head can be protruded as much as 1 cm. distal to the incisura angularis in any arc on the visual circumference of the field. The juxtapyloric portion of the antrum beyond, though readily seen, cannot be reached. Also, since the forceps is operated under visual control, the blind spots on the posterior wall and the greater curvature cannot be approximated. We have found that it is better to do preliminary routine gastroscopic study of the patient to confirm the clinical or the roentgenologic diagnosis before undertaking gastroscopic biopsy. Thus by doing two examinations the doctor is better orientated and the patient more cooperative.

The following abstracts of case records illustrate the adequacy of such stomach biopsies, taken with gastroscopic forceps. They also exemplify the high correlation in gastroscopic and pathologic diagnosis in our experience.

REPORT OF CASES

CASE 1.—E. F., a white man of 65, was admitted to the Barnes Hospital in April 1940, with a history and physical signs suggestive of gastric cancer. Gastroscopic examination was reported as follows: "In depth I, the angulus and antrum were grossly deformed by a mutilating, ulcerated, obviously malignant infiltrating lesion. In the center of this area, there was necrosis and minor bleeding. The pylorus was practically obliterated by the process, which extended up into the pars media (depth II) along the lesser curvature and posterior wall, involving approximately the entire distal half of the stomach. In the proximal portion (depth III), there were patchy areas of atrophic mucosa."

At a second examination, with gastroscopic forceps a specimen for biopsy was taken from the lesser curvature just proximal to the angulus. On microscopic examination there was found a marked amount of inflammatory reaction in all of this tissue. "The most significant feature is the number of atypical malignant glandular structures which are inserted in a loose type of connective tissue. The nuclei are very large and take a deep stain, showing several mitotic figures. The glandular structures are fairly well differentiated for the most part. However, there are a few cords of cells with typical malignant appearance around the

muscularis mucosae. The picture is typical of adenocarcinoma of the stomach" (fig. 2).

CASE 2.—C. H., a white man of 63, was referred to the gastroscopic clinic of the Washington University School of Medicine from the Barnard Free Skin and Cancer Hospital, where a diagnosis of lymphosarcoma had been made and gastric involvement suspected. On gastroscopic examination at depth I, the antrum was noted to be red, thickened and smooth, suggesting an infiltrating lesion. The angularis was stiff, but at the pylorus there were rhythmic contractions. At depth II on the posterior wall in the greater curvature, the mucosa was noticeably thickened and irregular, with polypoid protrusions showing changes of color as seen in the antrum; although resembling an abnormal diffuse infiltrating process, it was not similar to ordinary carcinoma and was certainly distinguishable from hypertrophic gastritis. On the anterior wall and lesser curvature, changes typical of gastric mucosal atrophy were present.

The gastroscope, with forceps in place, was then introduced and a biopsy specimen taken. Microscopic examination of this tissue showed absence of the gastric mucosa in many places. The stroma was densely infiltrated with a diffuse collection of lymphocytes in various stages of differentiation. While this appeared to be diffuse throughout, in one or two areas one could see a grouping together of these lymphocytes, with considerable variation in size and shape of the nuclei. From this study one can say that this was probably a collection of malignant lymphocytes, and the diagnosis of lymphosarcoma of the stomach was established (fig. 3).

CASE 3.—C. C., a 68 year old man, was seen in the dispensary of the Washington University School of Medicine in April 1942, where a roentgenographic diagnosis of carcinoma of the stomach was made. The report of the preliminary gastroscopic examination was as follows: "At depth I the angulus appeared normal. The mucosa of the antrum was thickened, red and nodular, giving the appearance of hypertrophic gastritis. The pylorus showed rhythmic closure. At depth II similar though more pronounced changes were noted in the distal half. As the fundus was approached at depth III, these gradually faded to a nearly normal appearance. At a second operation, a biopsy specimen was taken with a gastroscopic forceps from the anterior wall of the pars media. On microscopic examination the sections showed mucosa which was characterized by great thickening. The glands were hyperplastic, with occasional dilatations, and in some areas where the glands were cut longitudinally there was tortuosity. The cells of the glands were regular but showed numerous mitotic figures. In the stroma between the hyperplastic glands, a rather dense round cell infiltration with some fibroplasia was seen. A diagnosis of chronic hypertrophic gastritis was made" (fig. 4).

CASE 4.—I. W., a Negro woman of 34 years, was seen in the dispensary of Washington University School of Medicine in March 1941. Physical examination and gastrointestinal roentgenographic examination revealed no organic disease. Gastric analysis showed no free hydrochloric acid. Gastroscopic study was reported as follows: "At depth I the angulus, antrum and pylorus appeared normal. At depth II there were numerous patchy areas of mucosa showing thinning, with a grayish green color change and a visible vascular pattern of atrophic gastritis."

At a second examination a biopsy specimen was taken with the gastroscopic forceps from a characteristic area of the lesser curvature of the pars media. Microscopic examination showed the mucosa to present short, narrow crypts, leaving the glands which have their constituent cells and cell margins partly distorted and obliterated by chronic inflammatory reaction consisting of lymphocytic and plasma

Fig. 2.—Malignant transformation of gastric mucosa showing characteristic picture of adenocarcinoma. × 400.

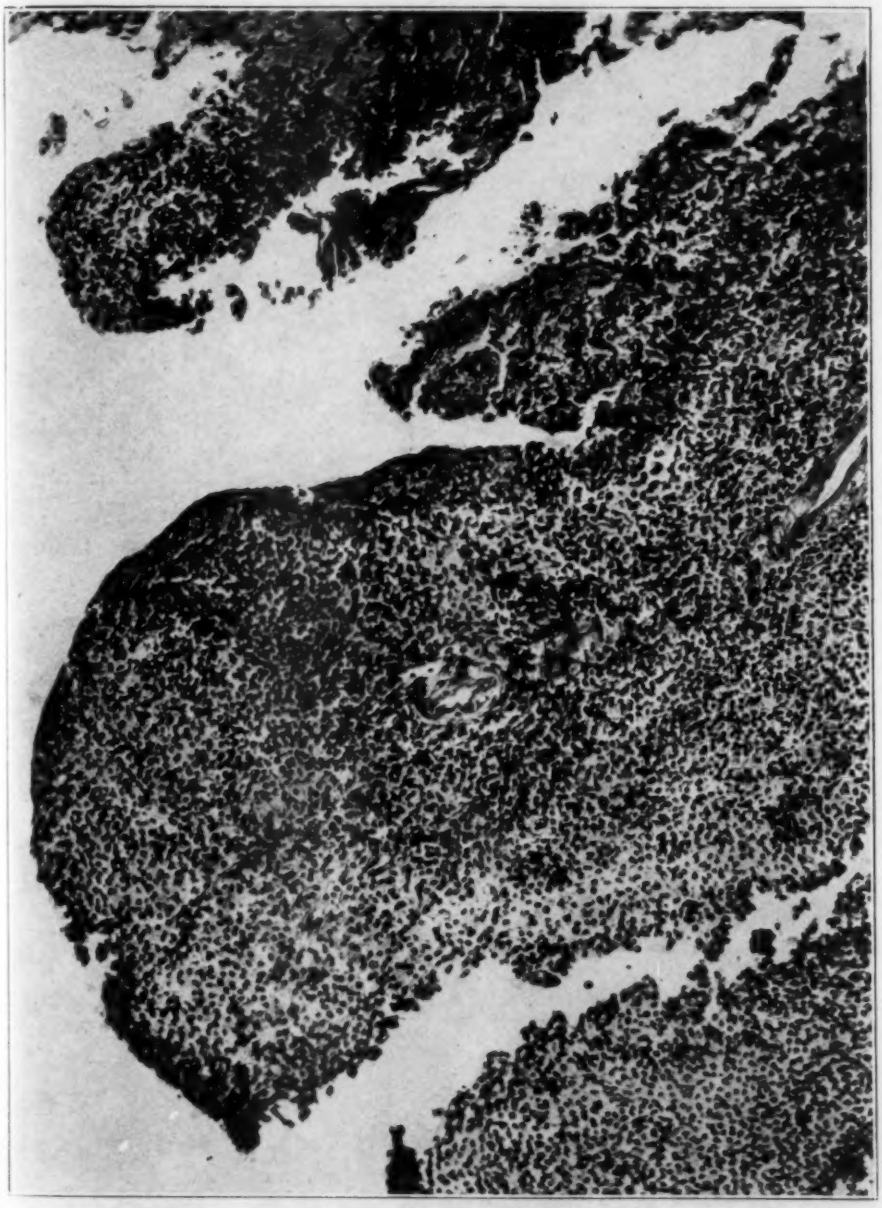

Fig. 3.—Destruction of normal mucosal architecture by diffuse infiltration with malignant lymphocytes. The picture is one of lymphosarcoma. × 400.

Fig. 4.—The mucosa is edematous and infiltrated with inflammatory cells. The picture is one of hypertrophic gastritis. × 400.

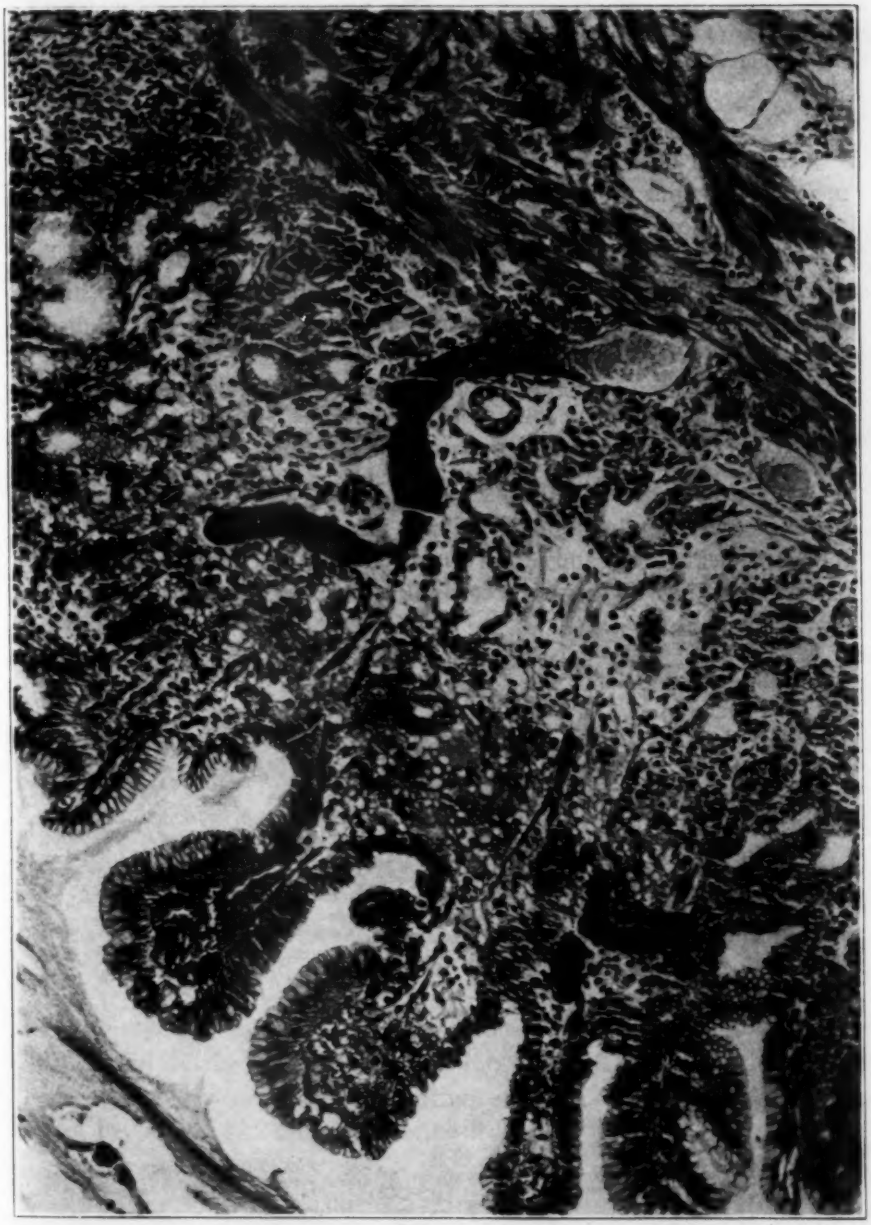

Fig. 5.—Mucosal atrophy is well illustrated. Note the blood vessel extending into the thinned submucosa. There are edema and infiltration by lymphocytes and plasma cells. The picture is one of atrophic gastritis. × 400.

cell infiltrations with a few polymorphonuclear leukocytes and moderate edema of the underlying stroma. The mucosal surface itself was covered by necrotic exudate and debris containing a few dead cells. The submucosa was largely replaced by collagenous fibrous tissue. There was noted considerable increase in vascularity of the submucosa. A diagnosis of chronic atrophic gastritis was made (fig. 5).

COMMENT

From the cases described, it would seem to us apparent that this means of examination has much to offer both the internist and the surgeon. It can be of definite value as a positive method of differentiating between benign and malignant gastric lesions. What may be more important, it provides a method of studying gastric mucosa before autolytic change can make its appearance in various types of disease and a method for studying the progressive changes occur that one might anticipate following certain therapeutic procedures.

SUMMARY AND CONCLUSIONS

Data accumulated in the use of the gastroscopic biopsy forceps for the microscopic study of gastric mucosa are presented. In trained hands the instrument is safe and offers a method of more exact study of gastric diseases. Abstracts of case records illustrate the diagnostic aid offered by this method.

DIVERTICULA OF THE STOMACH

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A DIVERTICULUM of the stomach is not a frequently encountered lesion, as is evidenced by the paucity of case reports, which now number some 150 cases. The table is offered to summarize the larger series reported, with the source of the material indicated when

Cases of Diverticula of the Stomach Previously Reported *

Author	Year	Number of Cases of Diverticula	Source of Cases			
			Autopsy	Operation	Barium Studies	Gastroscopic Examination
Larimore and Graham: Surg., Gynec. & Obst. 45 : 257, 1927	1927	3	.....	.....	3,446	
Sinclair [8]	1929	1				
Bell and Gordon: J. A. M. A. 94 : 534 (Feb. 22) 1930	1930	4				
Rivers et al.[7]	1935	4 25	3,662			
Martin [1]	1936	5				
Nathanson and Steiner [18]	1936	1				
Rigler and Ericksen: Radiology 26 : 6, 1936	1936	2	.....	.....	4,236	
Wigby [9]	1937	2				
Shiflett [11]	1937	43	.....	.....	786	
Cheney and Newell [13]	1937	2	.....	.....	11,828	
Schindler [22]	1939	3	.....	.....	.....	1,000
Reineke: J. Med. 22 : 152, 1941	1941	7				
Reich [3]	1941	8	.....	.....	19,022	
Schmidt and Walters [2]	1941	10	.....	11,234		
Love [16]	1942	1				
Balfour [6]	1942	9	2,506†			
Maissa [5]	1943	2	.....	.....	22,400	

* This table lists most of the reported cases of diverticulum of the stomach with the sources of the material in instances in which the source is mentioned.

† Gastric tumors.

significant. The somewhat dubious nature of many of the cases listed is suggested by the preponderance of those detected by gastrointestinal roentgenograms after a meal of barium sulfate, an examination which cannot be expected to differentiate the true diverticula from the pseudodiverticula in all instances.

According to Martin,[1] this condition was first described by Moebius in 1661 and by Fournier in 1774.

From the surgical service, Gallinger Municipal Hospital.

1. Martin, L.: Diverticula of the Stomach, Ann. Int. Med. **10**:447, 1936.

The anatomic sites of these diverticula have varied widely in the series reported. Schmidt and Walters [2] stated that most of them are found in the cardiac area on the posterior wall near the lesser curvature. Reich [3] reported 8 cases, in which all the diverticula occurred on the cardia, arising from the lesser curvature, and he attributed this distribution to a local predisposition due to splitting of the longitudinal muscle layer in this area into the muscular fasciculi, thus leaving only the circular muscle to cover the mucosa. Eusterman and Balfour [4] located 43 per cent of the anomalies in the fundus, 43 per cent in the prepyloric area and 14 per cent in the midportion of the stomach. Martin,[1] reviewing 103 cases, found sixty-three diverticula in the cardia, eleven in the midportion of the lesser curvature, fourteen in the prepyloric region of the lesser curvature, five in the midportion of the greater curvature, four in the prepyloric area of the greater curvature and six in miscellaneous sites. Maissa [5] localized most of them in the posterior wall of the cardiac portion and said that they are rare in the prepyloric region and greater curvature. In striking contrast, however, with these reports, Balfour [6] stated that the majority are found near the pylorus.

Analysis of the literature fails to reveal any particular predilection for either sex.

The age at onset of symptoms due to these growths is usually from 30 to 50 years. Rivers, Stevens and Kirklin,[7] reviewing 14 cases, found the youngest patient to be 26 years old. The ages of the 8 patients reported by Reich [3] ranged from 36 to 71 years. Much younger patients have been reported, however, in isolated protocols, such as the discovery of pathologic diverticula in an embryo by Broman and Pemkoff, in a 4 month old infant by Sinclair,[8] in a 7 year old child by Wigby [9] and in another child of the same age by Gile.[10]

2. Schmidt, H. W., and Walters, W.: Diverticula of the Stomach, Am. J. Surg. **52**:315, 1941.

3. Reich, N. E.: Gastric Diverticula, Am. J. Digest. Dis. **8**:70, 1941.

4. Eusterman, G. B., and Balfour, D. C.: The Stomach and Duodenum, Philadelphia, W. B. Saunders Company, 1935.

5. Maissa, P. A.: Gastroduodenal Diverticulosis, Prensa méd. argent. **30**: 2014, 1943.

6. Balfour, D. C., in Christopher, F.: Textbook of Surgery, ed. 3, Philadelphia, W. B. Saunders Company, 1942.

7. Rivers, A. B.; Stevens, G. A., and Kirklin, B. R.: Diverticula of the Stomach, Surg., Gynec. & Obst. **60**:106, 1935.

8. Sinclair, N.: Congenital Diverticulum of the Stomach in an Infant, Brit. J. Surg. **17**:182, 1929.

9. Wigby, P. E.: Diverticulosis: Two Cases, Texas State J. Med. **33**:43, 1937.

10. Gile, J. F.: Diverticula of the Stomach, New England J. Med. **204**:268, 1931.

These growths have been classified by Schmidt and Walters [2] as: 1. True (congenital) diverticula, in which all layers of the stomach are intact; they are due to malformation or interrupted development during the fetal period. 2. False (acquired) diverticula. The latter are of two types: (*a*) Pulsion type, e. g., those secondary to labor, pyloric obstruction, vomiting, coughing, constipation or foreign bodies. The authors feel that these are due to increased intraluminal pressure. These may also be caused by eroding lesions, such as gastric ulcers or carcinomas. (*b*) Traction type, e. g., those resulting from perigastric adhesions due to inflammatory lesions of the spleen, gallbladder and pancreas.

Shiflett [11] agreed with this concept in its essential details. Gile [10] said that the true type with all its coats intact is congenital, whereas the false types are mucosal hernias through the muscular walls. The views of Reich,[3] who considered these diverticula analogous to those of the esophagus, have been presented in the discussion of anatomic sites (see the following paragraphs).

These diverticula are usually pear shaped, with relatively small orifices, although wide-necked sacs are not unusual. Obviously, as with all diverticula, those with narrow necks have the greater potentiality for disease. In the series reported by Eusterman and Balfour,[4] the sacs had an average length of 7.5 cm. and a neck of 1 cm. in diameter. Rivers, Stevens and Kirklin [7] found that the masses varied from 1 mm. to 5 cm. in diameter. The mucosa of the stomach is continued into the diverticulum without interruption.

It is noteworthy that the majority are asymptomatic, the occurrence of this type being estimated by Rivers, Stevens and Kirklin [7] as 64 per cent.

Reich [3] asserted that there is associated gastroduodenal disease in 30 per cent of cases. Such accompanying lesions as have been reported are: (1) benign tumors in the sac (adenomas and myomas are described by Schmidt and Walters [2]); (2) malignant tumors in the mass, reported by C. H. Mayo,[12] Cheney and Newell [13] and Mellon [14]; (3) syphilitic ulceration as described by Joltrain [15]); (4) hiatus hernia; (5) hetero-

11. Shiflett, E. L.: Diverticula of the Stomach, Am. J. Roentgenol. **38**:280, 1937.

12. Mayo, C. H.: Diverticula of the Gastro-Intestinal Tract: Their Surgical Significance, J. A. M. A. **59**:260 (July 27) 1912.

13. Cheney, G., and Newell, R. R.: Large Diverticula of the Gastric Cardia, Am. J. Digest. Dis. **3**:920, 1937.

14. Mellon, R. R., and others: The Incidence of Carcinoma in Gastro-Intestinal Diverticulosis, Surg., Gynec. & Obst. **33**:177, 1921.

15. Joltrain, E.: Syphilitic Origin of Ulcer with Diverticulum, Bull. Soc. franç. de dermat. et syph. **43**:1643, 1936.

topic tissue in the diverticulum (Martin[1] has collected 15 cases of pancreatic inclusions); (6) recurrent and massive bleeding, such as given in case reports by Love,[16] Brown and Priestly[17] and Schmidt and Walters[2]; (7) duodenal ulcer, as in the case of Nathanson and Steiner[18]; (8) multiple diverticula, associated with diverticulosis of the colon and duodenum, occurring in 12 per cent of cases according to Eusterman and Balfour[4]; (9) diverticulitis, reported as not occurring by Reich,[3] but considered frequent by Maissa,[5] and (10) perforation and bleeding into the peritoneal cavity (this complication occurred in the case reported in this paper.)

The symptomatology of this condition has no features characteristic or even suggestive of the underlying pathologic condition. Its rarity will prevent acute mental awareness of the disease. At Mayo Clinic there was a preponderance of gastric malignant growths over this entity in a proportion of 266 to 1. The lesions which simulate it most closely are far commoner and occur in the same age groups. Such symptoms as are described in the literature in individual cases would not serve to differentiate it from any of a dozen other gastroduodenal afflictions. In general, the diagnosis will be ascertained only by roentgenologic examination, gastroscopic examination, operation or necropsy.

Reference to the table will reveal that the greater number of gastric diverticula have been revealed by roentgenologic investigations. The first such diagnosis was reported by Brown[19] in 1916. It must be realized, however, that certain precautions in interpretation of observations must be taken if large numbers of false positive diagnoses and errors of failure to demonstrate the lesion are to be avoided.

Akerlund[20] first listed the criteria for the diagnosis by serial gastrointestinal roentgenograms: (1) a mobile sac unattached to extragastric tissues; (2) a well defined, smooth and regular shadow, noted from various angles; (3) generally, no tenderness over the area of filling.

To these, Sandstrom[21] has added this criterion: (4) the presence of a nichelike opaque spot surrounded by a defect in the contrast shadow, the appearance of which resembles an ulceration without surrounding infiltration. This is best seen in a vertical position and during expiration.

16. Love, M.: Gastric Diverticula, Brit. J. Surg. **30**:180, 1942.

17. Brown, P. W., and Priestly, J. T.: Massive and Recurrent Hemorrhage from Diverticulum, Proc. Staff Meet., Mayo Clin. **13**:270, 1938.

18. Nathanson, L., and Steiner, M.: Diverticula at Cardiac End with Report of Case, Radiology **26**:326, 1936.

19. Brown, G. E.: An Unusual Stomach Case with Roentgenographic Findings, J. A. M. A. **66**:1918 (June 17) 1916.

20. Akerlund, A.: Diverticula of the Stomach from a Roentgenological Viewpoint, Acta radiol. **2**:476, 1923.

21. Sandstrom, C.: Contribution to the Roentgenological Appearance in Cases of Benign Diverticular Growths of the Stomach, Acta radiol. **10**:427, 1929.

Reich [8] has contributed these suggestions: (5) the demonstration of rugae in the mucosal lining of the neck by careful technic; (6) the location of the shadow, occurring most commonly at the cardia and the lesser curvature toward the posterior wall; (7) the retention of barium at the site of the shadow on a six hour plate; (8) the mucosal pattern of the stomach itself, soft, well defined and regular and showing no evidence of irritation (well defined rugae may lead right up to the diverticulum), and (9) occasional ability to empty the sac by changing the position of the patient.

Roentgenologically, the differential diagnosis between a penetrating ulcer and a diverticulum is based on the following points: In ulcer there is a tendency toward spasm near and opposite to the lesion and infiltration or rigidity of the mucosal border, features absent in the simple diverticulum. In addition, the gastric analysis and characteristic food-pain relationship may be hopeful.

In differentiating the diverticulum from a diaphragmatic hernia, the following features may be helpful: The diverticulum is larger during expiration; the reverse is true in hernia. A shadow in the chest is present in hernia. In hernia the shadow may be constricted where it passes through the diaphragm.

Gastroscopic examination may be of aid in the diagnosis. Schindler [22] discovered three diverticula during 1,000 gastroscopic examinations. Schmidt and Walters [2] said that gastroscopic examination will reveal a circular hole with a sharply defined margin and no sign of infiltration. The mucous membrane of the stomach surrounding the opening will usually be of normal appearance.

The treatment of choice in the cases in which symptoms are presented would seem to be surgical, as medical therapy could hardly be expected to eliminate the anomaly. The fear of carcinomatous degeneration is sufficient alone to recommend this manner of management.

We have recently had the opportunity to treat a patient with a gastric diverticulum which was involved in a complication not previously reported in the literature.

REPORT OF A CASE

A 33 year old Negro woman was first admitted to the hospital on March 7, 1945, with complaints of pains in the lower part of the abdomen for six weeks and vomiting for one week. Her pain had been gradual in its onset, becoming progressively severer, more cramping and more intermittent, with no tendency to radiate. She had noted urinary urgency and frequency for three months, but no pain in the back. There was no history of indigestion, melena, change in stool habits or hematemesis. In 1939 she had an operation for pyosalpinx, but her menstrual periods had been regular, asymptomatic and of usual duration, with no intermenstrual bleeding. Her last period was ten days prior to admission.

22. Schindler, R.: Incidence of Various Types of Gastric Disease as Revealed by Gastroscopic Study, Am. J. M. Sc. **38**:280, 1939.

On admission her blood pressure was 110 systolic and 70 diastolic, her pulse rate 112 per minute and her respiratory rate 32 per minute. The rectal temperature was 100.6 F. The significant signs in the physical examination were limited to the abdomen and the pelvis. Her abdomen was not distended but was acutely tender in all areas, especially in the lower portions. There was a moderate amount of muscular splinting throughout. Peristalsis was felt by all examiners to be depressed. Examination of the pelvis revealed what was considered to be a bogginess in the cul-de-sac, which was extremely tender. The laboratory tests showed a hemoglobin content (Sahli) of 50 per cent and a white blood cell count of 7,000. In view of these findings, an exploratory laparotomy was performed. The preoperative diagnosis was considered to be ectopic pregnancy.

Exploration was performed through a lower right rectus incision. When the peritoneal cavity was opened, about 1,500 cc. of blood was encountered. The pelvis showed no evidence of ectopic pregnancy. Further exploration revealed that the bleeding was originating from a rent in the gastrohepatic ligament but that no active hemorrhage was occurring at the moment. Owing to deterioration of the condition of the patient despite the parenteral administration of plasma and blood, the operation was concluded. The diagnosis seemed vague, but rupture of a gastrohepatic cyst was proposed as the probable diagnosis. The postoperative course was complicated by a bout of pyelonephritis. The patient was discharged on April 9, 1945, asymptomatic at the time.

On April 25 she was again admitted, with generalized abdominal pain of three days' duration, unassociated with nausea or vomiting. However, she stated that she had noted three tarry stools since her discharge. The abdomen was moderately tender in the epigastric region, but there was no indication of peritoneal irritation. The blood pressure was 135 systolic and 80 diastolic, the pulse rate 92 per minute, the respiratory rate 22 per minute and the rectal temperature 100.6 F. Laboratory examinations showed: hemoglobin content (Sahli) 56 per cent, red blood cell count 2,700,000 and white blood cell count 7,100. The urine contained many pus cells, occasional casts and albumin (2 plus), and there was a maximal specific gravity of 1.015 on the Fishberg concentration test. Stools contained blood on repeated tests. The total serum protein level was 6.2 Gm. per hundred cubic centimeters; bleeding, clotting and prothrombin times were normal. The result of a tourniquet test was normal. Gastric analysis showed free blood and normal free and total hydrochloric acid. Serial roentgenograms of the gastrointestinal tract revealed no lesion of the stomach or duodenum. The Kahn reaction was negative. With the conditions previously observed at operation in mind, the clinical picture seemed compatible with a diverticulum.

On May 7, with the patient under tetracaine hydrochloride spinal anesthesia, an exploratory operation was again performed through an upper midline incision. The entire upper part of the abdomen was occupied by extremely dense adhesions which had sealed all the organs in the area into a single mass. After lysis of these adhesions, the spleen was found to be extremely enlarged, obscuring almost the entire greater curvature of the stomach. The gastrohepatic ligament was greatly thickened and indurated. A perforation of a gastric ulcer into the spleen was now considered, and the stomach was opened in search of such a lesion. The entire mucous membrane lining the stomach was found to be normal in feel and appearance. In order to expose the posterior aspect of the stomach, it was necessary to remove the massive spleen. After the splenectomy, a bulbous mass was exposed behind the stomach, in the lesser omental sac, which was sealed off completely by the surrounding inflammatory reaction. This mass proved to

be the lower pole of the diverticulum and was dissected up to its junction with the posterior wall of the stomach in the cardiac region. It arose just posterior to the lesser curvature. Its base was excised and the hole in the stomach closed with a double row of inverting sutures. Now a very narrow neck could be demonstrated emptying into the lumen of the stomach through an extremely fine orifice. The mucosa of the stomach proper surrounding the orifice was normal in appearance and was continuous with the mucosal lining of the sac. The sac itself measured 11 cm. in length, with a maximal diameter of 3 cm. Microscopic examination of the diverticulum showed that its mucosal lining was extremely hemorrhagic and necrotic and that its muscular wall was fibrotic and infiltrated with hemosiderin deposits. The spleen showed only a generalized chronic inflammatory reaction.

COMMENT

The diagnosis in this case was not made either during or after the first operation until the additional symptom of melena was experienced. The combination of a known inflammatory mass in the gastrohepatic ligament with hemoperitoneum and a later episode of gastric bleeding, without evidence of gastric or duodenal ulcer, cirrhosis of the liver or bleeding diathesis, led my colleagues and me to suspect the presence of a gastric diverticulum, despite its rarity. Such fortuitous circumstances as these are exceptional. The operation appears to have relieved the discomfort of the patient.

SUMMARY

Diverticulosis of the stomach is an uncommon condition, as is evidenced by the fact that only about 150 cases have been reported. The most frequent site of occurrence is on the posterior wall near the lesser curvature in the cardiac region. In approximately 30 per cent of the cases there have been other associated gastroduodenal disease, which is more likely to cause symptoms than the diverticulum itself. About one in every three diverticula will be the site of adverse symptoms. The condition has no characteristic, or even suggestive, symptoms that would tend to differentiate it from other, far more common, lesions of the upper gastrointestinal tract. The eventual diagnosis will usually be made only on the observations at necropsy or at operation or by the results of several roentgenologic studies of the gastrointestinal tract or gastroscopic examination. It is easily missed by any of these methods.

A case is presented which illustrates rupture and bleeding into the peritoneal cavity due to a gastric diverticulum, which was diagnosed clinically by an uncommonly fortunate series of events. This complication of diverticulum of the stomach has not been previously reported.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1944

A Review Prepared by an Editorial Board of the American Academy of Orthopaedic Surgeons

XIII. Fractures

PREPARED BY WALTER G. STUCK, M.D., SAN ANTONIO, TEXAS; DON H. O'DONOGHUE, M.D., OKLAHOMA CITY; HERMAN F. JOHNSON, M.D., OMAHA; CHARLES J. FRANKEL, M.D., CHARLOTTESVILLE, N. C., and C. R. ROUNTREE, M.D., OKLAHOMA CITY

IN 1944, the most significant articles on fractures were concerned with the use of penicillin in compound wounds. Interest in external fixation devices was apparently waning as more of the limitations were becoming apparent. As in the past two years, the largest number of articles on fractures were those from men in military service, in which war experiences were recounted. Fortunately, this will be the last year that war surgery will play so prominent a part in current medical literature.

Fractures of the Upper Extremity.—Of all the articles examined on this subject, more than half described a common military injury in the upper extremity—fracture of the carpal scaphoid bones.

Greenlee [377] discusses posterior dislocation of the sternal end of the clavicle. Symptoms of encroachment on the trachea and the esophagus, as were present in the case reported, are of more importance than the dislocation itself. In the author's case, open reduction was done. No internal fixation was employed, but immobilization in a shoulder spica cast for five weeks was employed. The patient made a complete recovery. The diagnosis and treatment are discussed, the point being brought out that most surgeons prefer open reduction but a few advocate resection of the sternal end of the bone. A review of the literature emphasizing the paucity of articles on the subject is included.

Lee [378] describes an oblique fracture through the upper epiphysial plate of the humerus in which a spicule of the shaft is split off with the humeral head. The broad edge of the distal fragment protrudes through a small tear in the capsular extension of the shoulder joint, with the long head of the biceps tendon lying under the anterior edge of this fragment. Manipulation will not reduce these fractures, and operation is always indicated. The fracture site is approached through an anterolateral incision, care being taken not to damage the axillary nerve. The frac-

377. Greenlee, D. P.: Posterior Dislocation of the Sternal End of the Clavicle, J. A. M. A. **125**:426-428 (June 10) 1944.

378. Lee, H. G.: Operative Reduction of Unusual Fracture of Upper Epiphyseal Plate of Humerus, J. Bone & Joint Surg. **26**:401-404 (April) 1944.

ture is reduced, and fixation is done with a long vitallium screw. After closure of the incision, a shoulder spica cast is applied for six weeks. Three cases are reported. Treatment of the 3 patients brought excellent results. [ED. NOTE (L. D. B.).—Open reduction of epiphysial fractures of the upper end of the humerus are thought to be unnecessary by many of the writers on this subject.]

Gershman's [379] survey of orthopedic surgeons on requirements for an adequate first aid humerus splint for compound fractures reveals the importance of (1) speed of application; (2) comfort of the patient; (3) adequacy of the immobilization; (4) availability of mechanical appliances; (5) multiplicity of wounds, especially of the thoracic wall, and (6) difficulty of applying a cast to an anesthetized patient. The Jergesen "elephant trunk" splint seems to meet these requirements. It consists of anterior and posterior plaster splints from the fingers, up the forearm and arm and diagonally across the front and back of the chest. The shoulder is fixed in a position of 10 to 15 degrees of abduction, with 20 degrees of forward flexion, the elbow at right angles and the wrist dorsiflexed. [ED. NOTE.—This is, in effect, a light shoulder spica cast, which is well suited to emergency treatment of fractures of the humerus. It is not, of course, adequate for final fixation. The hanging cast is the ideal method for treating most fractures of the humerus, but it is of questionable value in cases in which transport is a major problem or in which wounds must be frequently examined.]

Loomis [380] calls attention to the fact that myositis ossificans more commonly affects the brachialis muscle than any other muscle of the body. It is also commoner following posterior dislocation of the elbow. The fibers of the brachialis muscle crossing the front of the elbow joint are torn and bruised after a posterior dislocation. This leads to loss of blood supply, with intramuscular hematoma and degeneration in the torn and bruised muscle fibers. Periosteal stripping of the capsule about the joint furnishes calcium. In the presence of these two factors preosseous substance may be formed. He believes that the usual method of reduction of the dislocation, consisting in extension and hyperextension of the elbow followed by traction and flexion, aggravates the damage to the muscle by further stretching and tearing the muscle fibers, thereby increasing the chances for myositis ossificans to develop.

The author advocates reduction with the elbow flexed to 90 degrees and the forearm in midposition. Strong traction is applied to the forearm with countertraction on the humerus. After traction, the elbow is

379. Gershman, M.: A Simple Method of Immobilizing Compound Fractures of the Humerus, M. Bull. North African Theat. Op. (no. 1) **2**:12-14 (July) 1944.

380. Loomis, L. K.: Reduction and After-Treatment of Posterior Dislocation, with Special Attention to Brachialis Muscle and Myositis Ossificans, Am. J. Surg. **63**:56-60 (Jan.) 1944.

flexed beyond 90 degrees to avoid fracture of the coracoid process, and strong pressure is applied to the anterior aspect of the lower part of the humerus, which effects the reduction. After reduction, a posterior plaster splint is applied with the elbow still flexed and the forearm in midposition. When the swelling has subsided, a light unpadded plaster cast is applied, extending from the axilla to the palm. The patient is encouraged to perform his usual work if possible. After three or four weeks, the cast is removed and a roentgenogram taken. If calcification is seen in the brachialis muscle, the cast is continued until the mass disappears.

In a group of 713 cases of fracture of the elbow in children below the age of 12 reported by Boyd and Altenberg,[381] there was this distribution of fracture types:

Types of Fractures	Approximate Percentage
Supracondylar fractures	65
Condylar fractures	25
Fractures of the neck of the radius	5
Monteggia fractures	2
Olecranon fractures	2
T-condylar fractures	1

In supracondylar fractures, the damage to nerves at the elbow or the circulatory disturbances are often more serious than the fracture. Uncomplicated supracondylar fractures are reduced by traction and direct pressure over the fragments. Fixation in acute flexion anchors them. Some irreducible fractures require operation to replace the fragments, followed by fixation with steel nails. Fractures of the external condyle of the humerus usually require open reduction to replace them and anchor them with a vitallium screw. Exact reposition is essential to normal growth of the elbow, and muscle pull makes it impossible to sustain the reduction without some type of internal fixation. Fractures of the medial epicondyle of the humerus generally require open reduction, exact replacement and fixation with a nail or screw.

Fractures of the neck of the radius in children should be treated conservatively by direct manipulation. It is undesirable to remove the radial head in children. Monteggia fractures (fracture of the shaft of the ulna with dislocation of the head) in children can usually be reduced satisfactorily without operation and secured by cast fixation. [ED. NOTE.—This is an excellent review of the fracture problems which are common in young patients and which are potentially the most disabling injuries in children.]

381. Boyd, H. B., and Altenberg, A. R.: Fractures About the Elbow in Children, Arch. Surg. **49**:213-224 (Oct.) 1944.

Dickson [382] points out that fractures in the middle third of both bones of the forearm are often difficult to maintain in proper position. The author has devised an ingenious and relatively simple method of securing the bones, by passing a Kirschner wire longitudinally through the medullary canal and across the fracture line. A slanting hole is made (in the lower end of the radius and in the upper end of the ulna), and the wire is pushed into the medullary space with pliers until it crosses the fracture line. If necessary, an incision is made over the fracture to secure proper apposition of the fragments. When the wire has passed the fracture line, the end is cut off and bent into a hook to facilitate its later removal. [ED. NOTE.—In a personal communication, the author stated that this operation is easier if the blunt end of the wire is inserted in the medullary canal and if the hook is bent in the wire before it is inserted. This appears to be a most useful method of anchoring these potentially troublesome fractures.]

Deterling [383] analyzes his series of 22 cases of Colles' fracture, covering a ten month period. He emphasizes the necessity for complete reduction, done with the patient under general anesthesia. A solid plaster cast extending to the elbow is employed for fixation. The hand is in palmar flexion and ulnar deviation. The fracture is kept immobilized until there is sufficient union as revealed by roentgenologic examination. This requires six to thirteen weeks. After removal of the cast, physical and occupational therapy is used.

Comminuted Colles fractures are treated with skeletal traction by means of a Kirschner wire through the first metacarpal bone or the proximal phalanx. A careful follow-up is of the utmost importance. Excellent results are reported.

Rogers [384] presents a review of 328 fractures of the lower end of the radius seen in St. Mary's Hospital, Paddington, England, in 1942 and 1943. There were 59 simple Colles fractures, 108 fractures with oblique posteromedial fragments involving both the radiocarpal and the radioulnar joints, 39 comminuted Colles fractures and 11 fractures with vertical fracture of the radial styloid process. [ED. NOTE.—The main point of this article is that "no two Colles' fractures are alike" and that roentgenograms should be carefully studied before treatment is begun, to make certain that the surgeon understands the problem before him.]

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382. Dickson, J. A.: Intramedullary Fixation of Certain Fractures of Both Bones of the Forearm, Cleveland Clin. Quart. **11**:62-66 (July) 1944.

383. Deterling, R. A., Jr.: Treatment of Colles Fracture, Pennsylvania M. J. **47**:583-586 (March) 1944.

384. Rogers, S. C.: An Analysis of Colles Fracture, Brit. M. J. **1**:807-809 (June 17) 1944.

Anderson and O'Neil [385] discuss the disability produced by the shortened and malunited lower end of the radius in comminuted Colles fractures. Attention is called to the difficulty in maintaining complete reduction due to the crushing of the cancellous bone of the lower end of the radius and the pull of the strong radial muscles. A method of skeletal traction in connection with skeletal halfpin countertraction and immobilization by means of two slender steel rods clamped to the traction pins, instead of a cast, is described. The traction wire is a 0.060 Kirschner wire passed perpendicularly through the distal third of the shaft of the second metacarpal bone or through the center of the first metacarpal bone. The wire is clamped to a U-shaped holder. Countertraction is obtained by placing two half-pins of 0.080 wire at an angle into the lateral aspect of the radius above the fracture. These are joined by two steel rods. The fracture is reduced with the patient under anesthesia and the apparatus adjusted to maintain reduction. The method is also applicable for arthrodesis and malunited fractures of the wrist. The period of immobilization and traction is much longer than that usually employed. Traction for ten to twelve weeks is recommended.

The article is well illustrated and the diagram clear and concise. [ED. NOTE (L. D. B.).—Most Colles fractures can be adequately treated by simple plaster fixation.]

Morton [386] states that fractures of the wrist and the hand are commoner in military surgery than in civil practice. Fractures of the scaphoid bone are relatively frequent and require long immobilization. For nonunion of this fracture, the Murray bone graft operation is much preferable to excision of the fragments. The author obtained solid bony union in 9 cases of bone grafts.

Fractures of metacarpal bones are common and are best reduced by direct traction or by use of the author's padded clamp. Immobilization is often secured by passing wires through the fractured bone into the adjacent intact metacarpal bone. The author also uses an external bar to anchor the protruding portion of the wires.

In fractures of the phalanges, longitudinal intramedullary wires are effective in securing fragments in proper position.

The author reports in detail 32 cases of fracture of the scaphoid bone. [ED. NOTE (L. D. B.).—In considering the use of wires and other devices for these fractures, it should be kept in mind that infection in the hand is a horrible complication.]

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385. Anderson, R., and O'Neil, G.: Comminuted Fractures of Distal End of the Radius, Surg., Gynec. & Obst. **78**:434-440 (April) 1944.

386. Morton, H. S.: Fractures of the Wrist and Hand, Canad. M. A. J. **51**: 430-434 (Nov.) 1944.

Bonnin and Greening [387] present a complete and detailed study of injury to the triquetrum. Two forms of indirect injury are discussed: (1) injuries by compression and (2) ligament traction (sprain) fractures.

Diagnosis of the injury by means of roentgenograms and physical signs is discussed. For the ligament traction fractures, immobilization in plaster for three weeks usually results in a complete clinical cure, although the fracture may not appear united in the roentgenogram. Compression fractures of the triquetrum of any severity require a longer period in plaster.

McKim [388] observed more than 125 fractures of the carpal scaphoid bone in two years in a Canadian army camp. They were treated by cast fixation for eight to ten weeks. Treatment was continued until there was roentgenologic evidence of solid bony union. All the fractures in this series obtained complete healing.

Dickison and Shannon [389] report on a series of 257 fractures of the carpal scaphoid bone seen in three years in the Canadian army overseas. The fractures which were not treated early showed the poorest results. All the fractures treated early gained adequate union. The worst error in these cases was failure of diagnosis at the time of the accident. In the cases of nonunion, bone graft is useful in obtaining union, but long postoperative fixation is essential. [ED. NOTE.—This article has much valuable detailed information about the various types of fractures. Interested persons would do well to go to the original article for the fine points of this problem.]

In two and a half years at a royal naval hospital, Robertson and Wilkins [390] treated 100 patients with fracture of the carpal scaphoid bone. The injury almost always followed a fall on the outstretched hand. A significant diagnostic sign was pain on percussion of the tip of the outstretched thumb. Four roentgenographic views were taken of suspected fractures to insure proper diagnosis. All patients were treated with nonpadded casts from the upper forearm to the metacarpal heads. The thumb was moderately extended, and this was found to be satisfactory without the extreme extension devised by Buxton. The average period of immobilization was twenty-six weeks. [ED. NOTE (L. D. B.). —The described multiview roentgenograms should be routine in the examination of all injuries about the wrist.]

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387. Bonnin, J. G., and Greening, W. P.: Fractures of Triquetrum, Brit. J. Surg. **31**:278-283 (Jan.) 1944.

388. McKim, L. H.: Fractures of the Carpal Scaphoid, Bull. Am. Coll. Surgeons **29**:142 (June) 1944.

389. Dickison, J. C., and Shannon, J. G.: Fractures of the Carpal Scaphoid in the Canadian Army, Surg., Gynec. & Obst. **79**:225-239 (Sept.) 1944.

390. Robertson, J. M., and Wilkins, R. D.: Fracture of the Carpal Scaphoid, Brit. M. J. **1**:685-687 (May 20) 1944.

Obletz [391] reports on 45 cases of fracture of the carpal scaphoid bone in young vigorous men in an army training camp during an eighteen month period. The lesion is rarely seen in older persons or in women of any age. A study of the blood supply to the carpal scaphoid bone revealed that every specimen examined had at least a few arterial foramens throughout the length of the bone. There was evidence of adequate blood supply to both the proximal and the distal portion in about 67 per cent of the bones examined. Fracture through the mid-portion of the bone could interrupt the blood supply to the proximal fragments in between 13 and 33 per cent of the cases. The fracture is produced by a fall on the outstretched hand, but the wrist is not hyperextended. A hairline fracture is produced usually through the mid-portion, without displacement of the fragments. Hyperextension of the wrist may result in separation of the fragments.

The fractures are divided into two types: type 1, fractures without interruption of the blood supply to either fragment, and type 2, fractures with interruption of the blood supply to the proximal fragment. Most of the fractures (37 cases) are type 1. In these cases, roentgenograms made three to four weeks following injury reveal the fracture line more distinct than at first, but there is diffuse homogeneous decalcification of both fragments of the scaphoid bone indicating normal blood supply. In six to eight weeks the fracture line is partially or completely obliterated and the decalcification process has stopped. There may be evidence of some recalcification. After the fracture unites and the cast is removed, the carpal bones resume their normal density.

There were eight fractures of type 2. These showed interruption of blood supply to the proximal fragment as evidenced by the normal density of the proximal fragment in the presence of generalized decalcification in all the bones. In these cases union occurs but much more slowly. This period of temporary avascularity is not to be confused with aseptic necrosis, because with proper protection and immobilization these fractures unite and the density of the bone is restored to normal. Temporary avascularity may lead to aseptic necrosis, however, if the revascularization process is inadequate or disturbed.

The author advises fixation of the arm from the distal palmar crease to the elbow, with the proximal phalanx of the thumb included. The patient is encouraged to use the hand as much as possible. The cast is worn until the fracture is healed. It may have to be replaced from time to time, however. No nonunions are reported in this series.

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391. Obletz, B. E.: Fresh Fractures of the Carpal Scaphoid, Surg., Gynec. & Obst. **78**:83-90 (Jan.) 1944.

Allen [392] found 6 cases of fracture of the carpal navicular bone in fifty-seven routine examinations of the wrist during a six month period. Clinical diagnosis of fracture of the navicular bone was made in only 1 case. Most of the fractures were diagnosed as sprain of the wrist.

Inasmuch as correct diagnosis and adequate immobilization are necessary for cure, an early diagnosis is important. In case of doubt, both wrists should be examined roentgenologically in anteroposterior views, lateral views and oblique views. Fibrous union, rather than bony union, often occurs.

Sometimes it is difficult to determine whether the fracture is old or recent. Decalcification, absorption of bone along line of fracture, efforts at repair or other signs may give a clue as to the age of the fracture, and each sign should be looked for and evaluated.

Henry [393] presents a good paper on fractures of the carpal scaphoid bone, calling attention to the fact that the lesion is frequently overlooked. Careful roentgenologic study of every "sprained" wrist in which pain persists longer than one week should be made. The roentgenogram is taken with the hand in sharp ulnar deviation, which brings the scaphoid bone into clear view and reveals many fractures which are missed with the usual position. During a five year period in a large industrial plant he was able to find 12 cases, whereas during a four month period at a large receiving and embarkation base he was able to find 22 cases. In practically all cases there is the same history of falling on the hand. He feels that the final result does not depend on immobilization or conservative treatment but rather on the site of fracture in the bone and whether or not the injury has destroyed or impaired the circulation to the bone, which is inadequate at best. Each fracture should be treated as an individual problem and the prognosis determined accordingly. Complete excision of the entire bone, done early, gives the best results. All dislocations of the scaphoid bone should be excised. Complete fracture through the middle to the inner third of the bone with displacement should be excised. Any crushing or comminution of the scaphoid bone should be treated by complete excision of the bone. Fissure fractures and fractures with no displacement may be treated conservatively.

In the industrial cases there was an incidence of 25 per cent of nonunion, and in the military cases 32 per cent of nonunion was reported. [Ed. Note (L. D. B.).—This author's treatment is not so conservative as that advocated by the other writers.]

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392. Allen, W. E., Jr.: Fractures of the Carpal Scaphoid, Mil. Surgeon **93**: 464-467 (Dec.) 1943.

393. Henry, M. G.: Fractures of the Carpal Scaphoid Bone in Industry and in Military Service, Arch. Surg. **48**:278-283 (April) 1944.

Webster [394] discusses the anatomy of the hand in relation to fractures of the metacarpal bones. By anatomic dissection and diagram, he shows that flexion of the terminal phalanges with the proximal phalanx in line with the metacarpal bones produces a resultant pull which tends to aline the fragments by taking advantage of the pull of the lateral muscles about the metacarpal bones. Treatment of these fractures by splinting on a straight board tongue blade or about a roll of bandage is condemned. He believes that constant skeletal traction with a small Kirschner wire through the proximal phalanx is indicated and necessary. The fracture is reduced with the area under local anesthesia, and a plaster cast is applied with the wrist hyperextended and the distal phalanges of the affected finger flexed. All other fingers, including the thumb, are free for active exercise. The cast is worn for four weeks, but full union does not occur until ten to twelve weeks. For malunited fracture, osteotomy with plating of fragments following correction of the deformity is employed. Special care is used to preserve the dorsal sensory nerves of the fingers.

Johnson [395] presents 2 cases of fracture of the thumb which were treated by passing a Kirschner wire through the first and into the second metacarpal bone. This produced locking of the fragments in perfect position, and the end results were excellent. [Ed. Note (L. D. B.).—If it is possible to reduce this fracture, simple plaster fixation will hold the reduction.]

Murless [396] reports a case of dislocation of the base of the fifth metacarpal bone, which was successfully treated by manipulation. These lesions are extremely rare, and no similar case has been reported in which manipulative reduction has been successful. The author feels that the successful outcome in his case was due to the fact that treatment was carried out six hours after injury. The hand was immobilized in a plaster cast for two weeks. An excellent review of the literature is included.

Fractures of the Spine.—Pittman [397] reports on approximately 100 patients with vertebral fractures who have been treated in seven years. The fractures have varied from fracture dislocations of the cervical portion of the spine, with paralysis and resulting death, to compression fractures of the lumbar part of the spine so slight that they were not discovered until roentgenograms were taken, weeks after the injury.

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394. Webster, G. V.: Simple Fractures of Diaphysis, U. S. Nav. M. Bull. **42**:623-640 (March) 1944.

395. Johnson, E. C.: Fracture of the Base of the Thumb, J. A. M. A. **126**: 27-28 (Sept. 2) 1944.

396. Murless, B. C.: Fracture-Dislocation of Base of Fifth Metacarpal Bone, Brit. J. Surg. **31**:402-404 (April) 1944.

397. Pittman, M. A.: What Practitioner Should Know About Injuries to the Spine, North Carolina M. J. **5**:43-48 (Feb.) 1944.

Kaplan and Wilson [398] present 3 cases of fracture of cervical vertebrae treated by use of Crutchfield tongs. These injuries resulted from diving into shallow water. One patient showed signs of severe injury to the cord, while the others had only slight damage to the cord in spite of severe injury to the cervical portion of the spine. The Crutchfield tongs, with traction of 15 to 25 pounds (6.8 to 11.3 Kg.), were used for three to four weeks and then plaster casts for six to twelve additional weeks. All patients were returned to full duty.

The authors point out that the amount of damage to the cervical part of the spine is not always comparable to the extent of injury to the cord. There are also cases of slow progressive changes in the cord, which are not evident at early examination. The first aid care that these patients receive is of utmost importance. The head should never be flexed, but traction in the supine position should be applied and maintained until the Crutchfield tongs are in place.

Crooks and Birkett [399] review a series of 59 cases of fracture of the cervical part of the spine under observation at the Nottingham General Hospital and the Chesterfield Royal Hospital.

Isolated fractures of spinous process are found in relation to fracture dislocation of the neck or as isolated fractures due to muscular or direct violence. The latter is described as "clay shoveler's fracture" by McKeller Hall (1940). When the injury results from the type of violence which would cause fracture dislocation but shows only a fractured spinous process, the treatment should be the same as if a fracture dislocation were evident. A "clay shoveler's fracture" is a comparatively innocent lesion.

The group of fracture dislocations of the series discussed were mainly to the upper part or to the lower part of the cervical portion of the spine, and of those fractures near the top of the cervical part of the spine fracture of the atlas and odontoid bones and displacement of the atloaxial joint have received adequate attention in the literature. The authors do not feel that the effect of the specialized anatomy of the axis and the effect of violence on it have been sufficiently realized. The weight of the skull is carried in front of the lower articular facets of the axis. The axis is supported in front by the disk below its body and behind by the relatively horizontal articular facets between its articular processes and those of the third vertebra. The axis has the only large and strong lamina and spinous process in the upper cervical region and has strong muscle attachments. Therefore, the sudden weight of the head, acting

398. Kaplan, A., and Wilson, J. D.: Cervical Spine Injuries: Treatment by Use of Crutchfield Tongs, U. S. Nav. M. Bull. **42**:443-447 (Feb.) 1944.

399. Crooks, F., and Birkett, A. N.: Fractures and Dislocations of Cervical Spine, Brit. J. Surg. **31**:252-265 (Jan.) 1944.

through the lateral masses of the atlas, falls anteriorly and may cause flexion of the neck and a glide of the axis forward. The axis may subluxate on the third cervical vertebra, or the strong group of posterior muscles may fracture the lamina or both may happen.

Conversely, any forced hyperextension at this level must be over the wedge of the articulation with the third cervical vertebra, and, if the force is great, backward displacement is possible after fracture of the body or tearing of the ligaments.

Prominence has been given this lesion, since out of the 52 cases of fractures of the cervical portion of the spine there were 6 at this level and the only real fractures of the lamina occurred in the axis and accounted for 4 of the 6 cases.

In a case of fracture dislocation, every effort should be made to reduce it completely and maintain position, even though a good functional result is possible without complete replacement.

Chronic arthritis may cause a special liability to injury to the cord in older people who fall heavily and fracture the lower part of the cervical column. Roentgenologic evidence of displacement may not be found, even though the patient may have complete paraplegia.

Easton and Sommers [400] present a series of 800 cases from six Ontario hospitals showing the incidence of fractured vertebrae in metrazol therapy. The incidence of fracture was 26.1 per cent. These occurred about twice as frequently in men as in women, and the number of vertebrae affected was greater in men. They believe this to be due to the greater muscular development in men. The incidence of fracture was greater in patients under 21 years, probably because at that age the full strength has not yet been attained. All fractures were in the dorsal portion of the spine, the fifth vertebra being the most frequently affected. All fractures were of vertebral bodies; the transverse and spinous processes were not affected. No dislocation occurred. No preexisting pathologic change, such as kyphosis, scoliosis or arthritis, increased the tendency to injury, but osteoporosis is a definite contraindication to metrazol therapy. In the cases in which curare was used to diminish the severity of the convulsion, the incidence of fracture dropped from 26.1 to 0.625 per cent. These also showed a decrease in the degree of compression and the number of vertebrae involved.

Ellis [401] reviews the differential diagnosis of changes of the vertebral bodies. Because of the construction of the spinal column, the majority

400. Easton, N. L., and Sommers, J.: Vertebral Fractures in Metrazol Therapy With and Without Use of Curare as Supplement, J. Nerv. & Ment. Dis. **99**:256-263 (March) 1944.

401. Ellis, J. D.: Compression Fractures of Vertebral Bodies and Other Changes Mistaken for Them, J. Bone & Joint Surg. **26**:139-145 (Jan.) 1944.

of compression fractures occur at the thoracolumbar junction. Since the force exerted on the superior part of the vertebral body is greater than that on the inferior part, almost invariably the fracture shows in the upper half of the vertebral body. Hollis Porter found only 1 fracture of the lower half of the vertebral body in a review of 500 consecutive compression fractures of the spine in which the arches were intact. The differentiation between old healed compression fractures and healed nontraumatic lesions is that in the fractures the wedging is roughly preserved and still affects the upper half only and the bone seldom resumes the appearance of the unaffected lower half. It has been shown by earlier research that general spondylosis and osteophyte production in the spine do not result from compression fractures of the vertebrae.

The wedged body of juvenile osteochondritis is distinguished from fracture in these ways: 1. The location is usually in the eighth to the tenth thoracic or the fifth lumbar vertebra. 2. Both upper and lower marginal rings are affected, and invariably there is a slighter degree of change in the adjacent vertebrae. 3. The general contour of the centrum is affected. 4. Scheuermann's nodes may appear. 5. Subsequent kyphosis is less angulated and involves both ends of the centrum.

Scheuermann's nodes may be differentiated from fractures because: 1. Nodes are most frequently found in the lower lumbar region, while fractures appear in upper lumbar and lower thoracic vertebrae. 2. The zone of separation is wide and clear, while a fracture shows irregular edges. 3. The node is larger than the usual marginal ring fracture. 4. More dislocation is evident in nodes. 5. The general contour of the centrum is unchanged with a node. 6. A fracture is due to a single injury, while a node is the result of abnormal lumbar extension strain.

Mainzer [402] reviews 63 cases of compression fracture of lumbar vertebrae, of which 32 were at the dorsolumbar junction, 22 of the second lumbar vertebra, 6 of the third lumbar vertebra and 3 of the fourth and fifth lumbar vertebrae.

A fracture of the vertebrae may be asymptomatic. The following signs and symptoms are indicative of a fracture of the vertebrae: (1) localized pain over the fracture site; (2) muscular rigidity of spinal muscles; (3) inability to stand erect; (4) weakness of the back; (5) retarded flexion at the fracture site, and (6) presence or lack of presence of girdle pains.

Anteroposterior and lateral roentgenograms are essential to show fracture and degree of dislocation. Forty-five degree oblique roentgenograms may also be of value. Gentle handling of the patient, with as little moving as possible, is necessary during the roentgenographic studies.

402. Mainzer, F. S.: Compression Fractures of Lumbar Vertebra Without Cord Involvement, Am. J. Surg. **64**:115-117 (April) 1944.

The treatment used in these cases was hyperextension, with forcible manipulation of the fracture and application of a plaster jacket as described by Davis.

Further treatment consisted in recumbency for three to fourteen days, after which the patients were allowed to be ambulatory. Casts were worn for four months and were followed by adequate braces. Postural exercises were started after removal of the cast. The majority of patients returned to their former occupations in five months.

A review of 19 cases of fracture of transverse processes of the lumbar vertebrae treated with local injection of procaine hydrochloride and early mobilizing exercises is presented by Nicholson and Allan.[403]

The diagnostic signs noted in these cases were list of the trunk to the affected side, painful flexion of the thigh against resistance on the affected side, discomfort increased by standing on the leg of the unaffected side and local tenderness and muscle spasm in the region of the injury.

Treatment consists in injection of 10 cc. of 1 per cent procaine hydrochloride solution into the region of the fractured transverse process as soon as the diagnosis is made and repeated on the second, fifth and eighth days if pain and muscle spasm persist. In no case has it been possible to demonstrate the presence of a hematoma at the fracture site. Exercises are instituted immediately after injection and consist in active hyperextension of the spine with the patient in the prone position, rotation of the shoulders in sitting position, lateral bending of the trunk and touching the finger tips to the floor in standing position. Each of these exercises is performed fifteen times, and they are repeated twice daily. Heat and light massage are given daily during hospitalization.

All patients without complicating injuries are kept ambulatory and have returned to duty in an average of ten days. The earlier treatment is started, the less time the patient is off duty.

The authors believe that, in accordance with the observations of Leriche, procaine eliminates pain, permits early mobilization and blocks vasomotor phenomena. Even though these patients may be symptom free in an average of ten days, the torn muscles and fascial structures are not yet completely repaired.

[Ed. Note (L. D. B.).—The experience of Dr. Nicholson and Dr. Allan in treating fractures of lumbar transverse processes is worthy of note. Following their directions, I treated unilateral fractures of three transverse processes in a halfback on a college football team. Two weeks following the injury the patient ran 65 yards (59.4 meters) 45

403. Nicholson, J. T., and Allan, J. H.: Fractures of Transverse Processes of Lumbar Vertebrae, U. S. Nav. M. Bull. **42**:780-785 (April) 1944.

yards (41.1 meters) and 19 yards (17.3 meters) for touchdowns and passed 18 yards (16.4 meters) for a fourth touchdown, to win the game 26 to 19. He complete the season without difficulty. Roentgenograms five weeks following the injury showed satisfactory union of all three fractures.]

Pusitz and Thompson [404] believe that 70 per cent of patients with compression fractures of the spine may return to their regular work provided there is complete reduction of the fracture, immobilization and proper fixation for long enough time and a program of muscle education carried out.

Reduction of the fracture should be done as early as possible, since delay makes the procedure more difficult and even incomplete. Even if complete reduction is not obtained, the rest of the routine should be carried out, as it will give a better end result.

The hyperextension cast is the best form of complete fixation. Movements of the unaffected joints is started as soon as patient recovers from the operation, usually in twenty-four to forty-eight hours. At the end of one month, the ambulant treatment will be started, the length of time the patient is out of bed being gradually increased until in six to eight weeks he is up as much as he desires.

The complete routine of the ambulant method is (1) from the beginning, movement of all joints not immobilized; (2) breathing exercises; (3) hyperextension of the head and shoulders, with the patient in the prone position; (4) hyperextension of the hip (single leg raising, then both); (5) with the patient strapped to table in the prone position, flexion of the body on the hips; (6) gluteal exercises, and (7), with the patient on his back, alternate straight leg raising.

In most cases the fracture will be healed when the cast is removed, in three to six months, and no support will be needed. If pain persists, exercises for mobilization of the spine are given as follows: (1) routine postural exercises; (2) in sitting position with hips abducted and body flexed on hips, flexion of the spine by placing the head between the knees followed by extension of the spine and (3) lateral flexion to the side opposite the muscular tightness.

Fractures of transverse processes should be treated by adhesive strapping if only one or two processes are fractured and there is little evidence of damages to soft tissues. If more processes are fractured, a plaster jacket should be applied. In either case active exercises are started from the beginning as described for fracture of vertebrae. Whether or not

404. Pusitz, M. E., and Thompson, I. E.: Physical Therapy in Compression Fractures (Without Cord Injury), Physiotherapy Rev. **24**:51-56 (March-April) 1944.

these fractures unite is of no consequence, but it is important to prevent massive formation of adhesions by active muscle education.

Fractures of the Pelvis.—Howell [405] reviews pelvic fractures. The complications in their order of importance are shock, injury to the urinary system, paralytic ileus, injury to nerve trunks and injury to the rectum. Hemorrhage from trauma to large vessels is rare.

All patients with pelvic fractures should be placed on a firm mattress with fracture boards or on a Bradford frame. Patients with fractures of individual bones without a break in the continuity of the pelvic girdle should be strapped with adhesive. [ED. NOTE (L. D. B.).—The strapping may cause more discomfort than the fracture.] After three to four weeks in bed, they may be allowed to use crutches, with a canvas belt. Normal function may be expected in ten to twelve weeks.

When the fracture causes a break in the continuity of the pelvic ring, the aforementioned treatment may be carried out if there is no displacement. If displacement has occurred, the hammock and spreader as described by Nolan and Conwell may be used with traction to one or both legs. The patient is allowed up on crutches after six to eight weeks with a pelvic girdle, and weight bearing is started in ten to twelve weeks. When these patients are not kept hospitalized, a double spica plaster cast may be applied after two to three weeks of the treatment mentioned and worn for six to eight weeks.

The double vertical fractures of the pelvis (Malgaigne fractures) and multiple fractures are best treated by the pelvic suspension frame with hammock and traction. Frequent roentgenologic examinations must be made, and if correction of the deformity is not accomplished manipulation with the patient under anesthetic may be done.

Musgrove [406] reports a fracture of the pelvis in a 40 year old man, a sedentary worker, who slipped on the ice and "did the splits." He experienced immediate and moderately severe pain in the adductor region of the right thigh. Walking aggravated the pain, and the patient limped considerably. In the hospital, he was thought to have a strain of the right adductor longus muscle at its origin from the pelvic bone and was treated with hourly hot packs. One week later pain persisted, and a roentgenogram revealed a fracture line across the inferior pubic ramus with two adjacent condensed lines, interpreted as buckling of the cortex.

After rest in bed for one month, the patient walked with little pain. Sixty-eight days after the accident he had been free of pain for two weeks, and a roentgenogram showed a fracture line transversing the

405. Howell, J. B.: Pelvis Fractures, Mississippi Doctor **21**:273-276 (March) 1944.

406. Musgrove, J. E.: Unusual Fracture of the Pelvis, Canad. M. A. J. **50**: 446-447 (May) 1944.

right inferior pubic ramus, with considerable callus formation. The author notes that these roentgenograms are almost identical with those of march fracture of the inferior pubic ramus described by Nickerson. Possibly the mechanism of this fracture is that the adductor magnus muscle caused a traction fracture in attempting to break the fall. If this is correct, similar repeated minimal strains which a soldier is liable to incur during training may be the cause of the march fracture of the pubis described by Nickerson.

Of 780 cases of fractures of the pelvis reviewed by McCague and Semans,[407] 133 patients, or 17 per cent, had accompanying rupture of the urethra or bladder. Of these, 99 had an intrapelvic urethral rupture; 1 a rupture of the anterior urethra; 22, rupture of the bladder; 11, combined urethral and vesical rupture.

Shock is severe in such cases. Cystostomy is required early to prevent urinary extravasation. Perineal drainage is usually necessary to prevent infection of the soft tissues about the urethra and the bladder. In the 133 cases studied in this series, there was a mortality of 23 per cent.

Adlington [408] presents a case of fracture dislocation of the symphysis pubis and dislocation of the right sacroiliac joint complicating rupture of a kidney and the spleen, with recovery. Other complications include bilateral bronchopneumonia, separation of wound and fecal fistula. This extensive injury to a 36 year old munitions worker resulted from being trapped between a 57 ton (51,710 Kg.) jib crane and a stack of 20 tons (18,144 Kg.) of 8 inch (20.3 cm.) naval shells.

On entrance to the Sheffield Royal Infirmary, the patient's blood pressure was 95 systolic and 75 diastolic; the pulse rate was 96 and of poor volume, and the abdomen was tender, slightly distended and immobile. There was tenderness over the lumbar portion of the spine, but there was no sign of injury to the central nervous system. There was remarkably little bruising or abrasion.

Immediate splenectomy and nephrectomy were performed, with concurrent treatment of shock. Treatment of the dislocated pelvis consisted in immobilization between sandbags and use of a pelvic binder. The patient could walk rather well and was free from pain on dismissal.

Fractures of the Femur.—Swart and Miyakawa [409] give their experience with the treatment of one hundred and eighty-four fractures of the femur in 179 patients. For twenty-eight fractures of the neck of the

407. McCague, E. J., and Semans, J. H.: The Management of Traumatic Rupture of the Urethra and Bladder Complicating Fracture of the Pelvis, J. Urol. **52**:36-41 (July) 1944.

408. Adlington, S. R.: Dislocations of the Pelvis with Traumatic Rupture of Kidney and Spleen, Brit. J. Surg. **31**:407-408 (April) 1944.

409. Swart, H. A., and Miyakawa, G.: Fractures of the Femur: Results of Treatment of 179 Patients, Am. J. Surg. **65**:221-225 (Aug.) 1944.

femur, the results were considered excellent in 17 per cent and good in 39 per cent. The authors feel that failures most often result from damage to the blood supply at the time of the accident.

In treatment of the 36 intertrochanteric fractures in this group excellent results were attained for 27 per cent and good results for 30 per cent. The most favored form of treatment was well leg traction by the Roger Anderson or the Carl Jones method.

There were 23 fractures in the upper third of the shaft, with excellent results in 34 per cent and good results in 39 per cent. Skeletal traction was moderately successful in most cases, but when there was a short upper fragment a vitallium plate on the bone was often necessary.

The 69 fractures of the middle third of the femur led the authors to believe that Russell traction was the best form of treatment.

There were 28 fractures of the lower third of the femur, and these were best treated by use of two or even three Kirschner wires in order to correct all the various displacements.

Hart [410] describes the best type of treatment for every type of fracture which can occur in the adult femur. He emphasizes correctly the importance of preserving function of the joint and muscle tone during the long period of immobilization needed for most of these fractures. An especially good point is the author's preference for placing Kirschner wires through the upper end of the tibia rather than the lower end of the femur. Wires through the femur restrict the gliding mechanism of the femoral fascia, cause synovial and capsular adhesions and encourage quadriceps atrophy. [ED. NOTE.—The author speaks of keeping patients in bed with traction "until there is radiographic evidence of good bony union between the fragments." Stability of the fracture or its resistance to attempted bending will often be adequate before there is roentgenologic proof of callus formation, and it can be assumed that healing is far advanced whether the roentgenologic evidence is satisfactory or not.]

Bush [411] has treated 39 patients with fracture of the femur, using manipulation or preliminary traction followed by immobilization in a double hip spica. The author claims that hospitalization is shortened, care is eased and the children are more comfortable.

Briones Olivos and Gebauer [412] report on 12 cases of fracture of the femoral shaft treated by double skeletal traction. The place of transfixion with Kirschner wire is at the level of the anterior tubercle of the tibia and

410. Hart, V. L.: Treatment of Fractures of the Adult Femur, Mil. Surgeon **95**:379-384 (Nov.) 1944.

411. Bush, L. F.: Treatment of Fractures of the Femur in Children, Am. J. Surg. **64**:375-378 (June) 1944.

412. Briones Olivos, J., and Gebauer, T.: Diaphysial Fractures and Their Therapy with Double Skeletal Traction, Arch. Soc. cirujanos hosp. **13**:29-34 (June) 1943.

the distal fragment of the femoral shaft or the supracondylar fragment. Patients are placed on a hard bed with a Braun splint adapted to the traction procedure. Transtibial traction is maintained for an average of forty days and transfemoral or supracondylar traction for thirty days. A plaster of paris cast was applied to 11 patients to complete treatment.

The time required for recovery was seven months and twenty days. Two patients required operation, one because of delayed union in a compound fracture with interposition of muscle and the other because of formation of a vicious callus due to vicious bony union. These complications were not due to the method.

Hampton [413] describes in detail the importance of proper placement of the traction wire in the lower end of the femur and of the adjustment of overhead traction with longitudinal traction. There are excellent drawings to demonstrate the application of the Thomas splint and slings and of the means for leaving access to wounds. The external traction apparatuses were found not adaptable for treatment of battle fractures.

In World War I, compound fractures of the femur caused 17 per cent mortality. In the North African campaign, in one hospital there was 1 death in 83 cases. As the war moved into Italy, sepsis increased, but in another group, of 193 cases, there were only 3 deaths.

Jack,[414] working in the Middle East, found that patients with fractured femurs presented difficult problems. There were long ambulance journeys over rough roads, unpredictable delays and inadequate facilities for treatment en route. Consequently, special methods of transport of these patients had to be worked out to prevent shock and suffering while at the same time reasonable apposition of the fracture fragments was being preserved. An Australian hospital at Tobruk devised the plaster cast and splint combination ("Tobruk splint"), which solved this special problem better than any other methods. By use of adhesive skin traction and the Thomas splint with a supporting cast about the thigh and leg, these patients were transported with a minimum of discomfort until they could reach the base hospital. This is recognized as a compromise procedure, but it was the best that could be done for the patients in the unusual circumstances seen in the early African campaigns.

Automobile accidents, paratroop training and landing operations are the cause of a large percentage of fractures of the femur. MacPherson [415]

413. Hampton, O. P.: Observations on the Use of Balanced Skeletal Traction for Battle Fractures of the Femoral Shaft, M. Bull. North African Theat. Op. (no. 3) **2**:46-51 (Sept.) 1944.

414. Jack, E. A.: Evacuation of the Fractured Femur, Lancet **2**:11-13 (July 1) 1944.

415. MacPherson, F. L.: Symposium on War Surgery: Femoral Plating with Fixation by Townsend and Gilfillan Plate, S. Clin. North America **23**:1623-1626 (Dec.) 1943.

advocates treating the patients first by the application of skeletal traction through the distal end of the femur. If reduction is obtained in seven days, the traction is continued. When traction fails, the fracture is plated, with use of two Townsend and Gilfillian plates nested together to provide added strength. Large comminuted fragments are first fixed with a separate screw placed away from the site of plating. No external fixation is used. The author claims reduction in length of disability of 50 per cent over other methods. [Ed. Note (L. D. B.).—Seven days is not long enough time to wait for reduction by traction.]

Charnley [416] analyzes the mechanical factors underlying the reduction and fixation of fractures of the femoral shaft. He contends that the criteria for good results are (1) correction of shortening and angulation and lateral displacement and (2) immobilization. He feels that fixed traction in a Thomas splint is the most satisfactory method. Detailed mechanical data are presented to prove his contention.

Masland [417] describes a splint for fractures of the femur which secures traction by a cast on the leg and countertraction by a pelvic ring. Pressure is increased by turnbuckles, which can be adjusted, to recover length of the extremity. This splint which he has used for twenty years is efficient in reducing and maintaining fractures. [Ed. Note.—In the hands of such an experienced person as the author, this splint apparently functions well. It is difficult to see, however, how a less capable surgeon could avoid pressure sores on the foot or leg from this powerful turnbuckle traction.]

Fractures of the Leg.—Savini [418] emphasizes again the importance of immobilization of fractures of the lower extremity preliminary to moving the patient. The particular appliance which he recommends is a board large enough to be placed under the patient and to support both lower extremities by suitable webbing straps. It certainly is a principle of "splint them where they lie," and it is worthy of reemphasis. The apparatus he suggests appears to be practical for lay use.

Curry [419] describes a novel type of splint for the lower extremity, made of a pneumatic encasement for the whole limb. It buckles about the injured extremity and provides even, steady support, with great relief from pain on movement. [Ed. Note.—This is an ingenious idea and has merit if such splints can be manufactured at reasonable cost.]

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416. Charnley, J.: Mechanics of Reduction and Fixation of Fractures of the Shaft of the Femur, Lancet **1**:235-239 (Feb. 19) 1944.

417. Masland, H. C.: Modern Fracture Deformity Reducing Splints, Am. J. Surg. **66**:182-188 (Nov.) 1944.

418. Savini, C.: Transportation of Patients with Fractures of Lower Extremities, J. Bone & Joint Surg. **26**:406-407 (April) 1944.

419. Curry, G. J.: A Pneumatic Leg Splint, J. A. M. A. **125**:966-968 (Aug. 5) 1944.

Blumenfeld [420] reports 3 cases of serious complications following use of the Anderson skeletal fixation device for fractures of the leg. In the first case there was extensive infection of the soft tissues, sloughing and paralysis of the anterior tibial muscle. In the second case, infection developed later, but the peroneal palsy was evident from the first, which probably meant that the peroneal nerve was damaged when the upper pin was inserted. In the third case, infection of the soft tissues followed insertion of the pins. [ED. NOTE.—While these are extreme illustrations, they emphasize once again the dangers inherent in external fixation of fractures. In the hands of the experts and the principal proponents of this method, infection about the pins may be negligible. Still, any method of treatment of fractures must meet the stiff requirements of being suitable for use under varied conditions and in the hands of many different surgeons.]

Goldberg [421] describes a makeshift "walking heel" which meets the requirements of any kind of walking cast. A discarded rubber heel is nailed to a block of wood 5/8 inch (1.6 cm.) thick, 3 inches (7.6 cm.) wide and 7½ inches (19 cm.) long. This is incorporated into the sole of the leg cast.

Ligament Injuries and Sprains About the Ankle.—During the past year there have been many excellent articles concerning painstaking work in regard to treatment of injuries to ligaments about the ankle. Needless to say, there is still great discrepancy of opinion as to the proper method of treatment of the "sprained ankle." It should be emphasized that it is extremely important to differentiate between minimal damage to a ligament and major injuries involving loss of integrity of the ligaments. This is brought out by Ball and Egbert,[422] who call attention to the fact that in the normal anteroposterior roentgenogram of the ankle joint there cannot be a translucent zone between both the talus and tibia and the talus and fibula. If such a zone is visible on both sides, it indicates damage to the tibiofibular ligament, with wideness of the ankle mortise. They point out that failure to recognize such a space will result in inadequate treatment, with permanent disability.

Wright and Parker [423] also emphasize the importance of separating so-called simple sprains from serious injuries to ligaments. They state that, in their opinion, failure to recognize complete rupture of a liga-

420. Blumenfeld, E.: Footdrop Following Skeletal Fixation, Bull. U. S. Army M. Dept., December 1944, no. 83, pp. 73-76.

421. Goldberg, D.: A Practical Walking Cast for Use Under Wartime Conditions, Mil. Surgeon **95**:151-153 (Aug.) 1944.

422. Ball, R. P., and Egbert, E. W.: Ruptured Ligaments of Ankle: Roentgen Sign, Am. J. Roentgenol. **50**:770-771 (Dec.) 1943.

423. Wright, J. M.; Parker, L. O., and Lehan, T. R.: Sprained Ankles, U. S. Nav. M. Bull. **42**:1309-1313 (June) 1944.

ment, with subsequent inadequate immobilization, is largely responsible for chronic and recurrent sprained ankles. In many of their cases complete rupture of the lateral ligament of the ankle was found much more commonly than rupture of the internal ligament. They recommend an anteroposterior roentgenogram of the ankle made with the foot passively adducted, so to put strain on the lateral ligament, which will permit some subluxation of the talus in the ankle mortise if the lateral ligament is torn. In their opinion, this is sufficiently important to justify the use of an anesthetic in order to determine a rupture of a ligament in a doubtful case. Anesthesia is induced by injection of 20 or 30 cc. of 1 per cent procaine hydrochloride solution. If rupture of a ligament is found, a nonpadded plaster cast with walking stirrup is applied. Immediate walking is urged, and the cast is left in place for six weeks followed by adhesive strapping for another two weeks. For the so-called simple sprained ankle, without serious ligament injury, a pressure bandage with injection of procaine hydrochloride solution, massage and early use is recommended.

A contrary opinion is expressed by Webber,[424] who advised that there are distinct disadvantages to the three common methods of treatment for a sprained ankle, namely, rest in bed, exercise and strapping. He indicates that muscle spasm, pain, venous stasis and lacerated ligaments are the common pathologic findings, and he adds that vasoconstriction is increased by strapping while muscle spasm and pain are increased by early weight bearing and pull on the injured ligament. He feels that putting the patient on his feet too soon after injury will cause other chronic foot conditions, such as warts, calluses and synovitis. His technic varies somewhat from that usually employed in that he recommends injection of procaine hydrochloride to the talocalcaneal joint space. By careful roentgenologic study, he was able to demonstrate in many cases a distinct widening of the talonavicular and the calcaneocuboid joint space, probably by the pressure of a hematoma, and, in his opinion, this accounts for the deep aching in the foot and up the back of the leg which was observed in his early cases, in which the patient did not have the benefit of talocalcaneal injection. After the injection, the patients were sent back to full duty, with apparently satisfactory results.

Cleveland, Willien and Doran [425] present an interesting paper, pointing out the contrast in treatment of soldiers and civilians. Since a soldier can be kept under careful observation, because he must be kept

424. Webber, J. T.: Ambulatory Treatment for Sprained Ankles, West Virginia M. J. **40**:176-178 (June) 1944.

425. Cleveland, M.; Willien, L. J., and Doran, P. C.: Treatment of Undisplaced Fractures at Ankle Joint, Bull. U. S. Army M. Dept., June 1944, no. 77, pp. 103-105.

in the hospital until his return to active duty, and can be kept entirely under the control of the medical staff, medical officers have attempted to reduce the hospital stay by elimination of the early period of immobilization. In a group of patients with fractures about the ankle joint, notably the lower part of the fibula, without displacement, it has been observed that following use of a plaster cast the period of rehabilitation after the cast is removed is often longer than the period of immobilization itself, a period characterized by swelling, pain on weight bearing and limitation of motion. Two parallel series of patients were observed, 32 patients receiving immobilization and 32 patients receiving a regimen consisting in rest in bed, elevation, ice packs, early active mobilization and weight bearing as soon as soft tissue damage had apparently subsided. No manipulation was carried out, and careful roentgenologic study was made to determine complete integrity of the ankle mortise. Treatment of the injury to the joint itself was considered subordinate to early weight bearing and was supplemented by hydrotherapy, massage and gentle manipulation. In this series, the number of days of duty lost by immobilization in plaster followed by physical therapy was 57.3 days, while the time lost in the series of patients without immobilization was reduced to 35.7 days. It was emphasized that complete and continuous control of the patient is essential.

Because of extreme disability which follows improperly reduced fractures of the ankle, Burgess [426] has made it a rule in recent years to do "routine open reductions of all fractures of the ankle with displacement." Fractures of the medial malleolus are replaced and anchored by a single vitallium screw. Bimalleolar fractures are treated in the same way, and the vitallium screw in the medial malleolus is sufficient to hold both fragments in proper position. Fractures of the lateral malleolus are reduced and anchored by passing a vitallium screw through the distal fragment and into the lower end of the tibia. Trimalleolar fractures (with the posterior tip of the tibia fractured off) are reduced and vitallium screws placed through the medial malleolus and the posterior malleolus. Diastasis of the inferior tibiofibular joint is treated by a screw placed through the lower end of the fibula into the tibia in an oblique direction (to prevent stripping of the screw threads).

After using these methods in 46 cases, Burgess feels that the results are better because the foot is held in the normal neutral position in the cast, early weight bearing in a cast is possible and the entire period of cast immobilization is shorter.

[ED. NOTE.—While the author's points are well taken, we have always felt that fresh fractures of the ankle were among the easiest to reduce. It is true that walking casts have no place in the treatment

426. Burgess, E.: Fractures of the Ankle, J. Bone & Joint Surg. **26**:721-732 (Oct.) 1944.

of fractured ankles unless the fragments are anchored by screws. Most nonunions of ankle fractures result from too early weight bearing. If this method eliminates late stiffness of the ankle when used by many surgeons, it has merit. On the other hand, it seems radical to advise "open reduction of all fractures of the ankle with displacement."]

O'Shea [427] reports 2 cases of fracture of the calcaneus with dislocation of the subastragaloid joint, pointing out that this rather unusual type of injury is not to be confused with total dislocation of the talus. He indicates that careful roentgenologic study will reveal the pathologic changes and that each patient must be sharply individualized for the method of treatment. It was emphasized that this gross displacement causes pronounced impairment of circulation of the foot, and O'Shea discusses at length the blood supply in this area. The ankle mortise is not disturbed, the dislocation occurring between the talus and calcaneus and the talus and navicular bones, with the probability of tendons and ligaments being wedged into the luxated joint. This is often attended by other fractures of the foot. He particularly stresses the importance of early reduction of the joint, with the patient under general anesthesia. Following reduction, immobilization in a plaster cast extending from the midthigh to the toes, with the foot at a right angle, should be used and maintained for eight weeks. If there should be any question about the completeness of reduction, open intervention should be done. Should reduction be long delayed, open reduction with subastragaloid arthrodesis is the procedure of choice.

Gill [428] presents a description of a method for reduction and fixation of fractures of the os calcis, telling about reduction by skeletal traction with the patient lying on his face in order to permit better accessibility for the traction. This is followed by fixation with pins through the cuboid and the talus bone and a sagittal pin through the os calcis. If this fracture is not of a comminuted type, only the sagittal pin will be necessary. [ED. NOTE.—Details must be sought in the original article.]

McBride [429] describes a method of treating fractures of the calcaneus bone by the use of three pins, threaded bars and nut traction tubes. A pin is placed through the tibia 4 inches (10 cm.) above the ankle, another through the base of the metatarsals and the third through the tuberosity of the calcaneus.

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427. O'Shea, M. C.: Subastragaloid Dislocations, with Report of Two Cases of Dislocation of Subastragaloid Joint and Fracture of Os Calcis, New York State J. Med. **44**:49-55 (Jan. 1) 1944.

428. Gill, G. G.: Three Pin Method for Treatment of Severely Comminuted Fractures, Surg., Gynec. & Obst. **78**:653-656 (June) 1944.

429. McBride, E. D.: Fractures of the Os Calcis, J. Bone & Joint Surg. **26**:578-579 (July) 1944.

Compound Fractures and Battle Fractures.—Macdonald's [430] report covers cases observed during 1941, 1942 and 1943 at a New Zealand hospital unit in the Middle East. His observations early in the war showed that it was a mistake to attempt to suture wounds primarily at front line hospitals. Surgeons soon found that wounds thus treated always became infected.

Also early in the war débridement or "excision of the wounds" often led to unnecessarily drastic removal of soft tissues. Too much petrolatum gauze was used in wounds in an effort to produce a "petrolatum plug." By all odds, it was found that the Thomas splint was the safest and the most efficient device for the transportation of patients with fractured femurs. The most troublesome wounds were those received in mine accidents, with compound fracture of the bones of the feet.

Jeffrey [431] reports on the use of penicillin in Italy. In January to June 1944, the use of penicillin was started for all severe compound fractures. In the forward areas, wounds were excised, insufflated with penicillin-sulfathiazole powder and packed open with petrolatum gauze. At the base hospital, the wounds were partially sutured, and patients were given penicillin systemically in doses of 15,000 units every three hours for five to ten days.

One hundred and fifty patients with fractures of the femur were so treated, and only 25 per cent showed persistent minor infections three months later. Adequate dosage of penicillin and early partial suture of wounds produced much less dense scars and more rapid healing of the fractures.

Jeffrey and Thomson [432] report that gas gangrene increased as the war moved from the Middle East (3.4 per 1,000) to Tunisia (6.7 per 1,000) to Italy (10 per 1,000). The mortality was about 50 per cent.

Thirty-three patients in Italy in the spring of 1944 were treated by radical incision, gas gangrene antitoxin and penicillin. Twelve of the patients died, but in some instances death occurred from late renal failure. In all cases there was a striking arrest of the gangrenous process, although late toxic effects from the infection were often observed.

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430. Macdonald, A.: Observations on Battle Casualty Compound Fractures and Joint Injuries in the Middle East, New Zealand M. J. **43**:172-176 (Aug.) 1944.

431. Jeffrey, J. S.: Battle Casualty Fractures in Italy: Treatment with Penicillin, Brit. J. Surg. (supp.) **32**:144-147 (July) 1944.

432. Jeffrey, J. S., and Thomson, S.: Gas Gangrene in Italy: A Study of Thirty-Three Cases Treated with Penicillin, Brit. J. Surg. (supp.) **32**:159-167 (July) 1944.

McEwan and Bickerton [433] report on 12 battle casualty fractures of the femur treated by intramuscular injections of penicillin at an orthopedic center in Italy in 1944. Nine of the fractures healed primarily, and the bony union proceeded normally. The other three fractures were still open after three months, but in only 2 was there any evidence of infection of the bone.

Mech [434] states that penicillin is the most potent antibacterial agent available for the treatment of compound wounds. The author used large doses, 25,000 units every three hours, and felt that this was more effective than use of smaller doses. Equally important is close consideration of the patient's general nutritional status.

Moore [435] gives a good sketch of the development of knowledge of the growth of bone and of the evolution of bone grafting. There are, in addition, excellent diagrams of the various bone-grafting methods which have been proposed in recent decades. The modern massive bone grafts immobilized with metal screws and supported by external casts provide a high percentage of unions in old ununited compound fractures.

Snyder's [436] statistics show that 60 per cent of the battle casualties admitted to Fifth Army hospitals had wounds of the extremities. Under battle conditions, all patients were stripped of clothing to make possible complete examination of the body. This was necessary to prevent the overlooking of small wounds. In general, all treatment was given with the patient under general anesthesia.

Wobbling rifle bullets produced explosive effects in tissues similar to those produced by high explosive fragments. Hence all such wounds required excision of tissue more extensive than the simple débridement. Primary nerve suture was not satisfactory, but damaged nerves were identified and reported in the patient's record. Primary tendon suture was likewise unsatisfactory. Clean through and through wounds required adequate exploration and drainage to prevent gas gangrene.

Adequate early operation was the only way by which serious complications such as cellulitis, gas gangrene and abscesses could be prevented.

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433. McEwan, R. J. B., and Bickerton, J. J.: Battle Casualty Fractures of the Femur: Treatment with Penicillin, Brit. J. Surg. (supp.) **32**:154-158 (July) 1944.

434. Mech, K. F.: Wound Healing in Compound Fractures and Repair of Bone Defects, J. Bone & Joint Surg. **26**:442-447 (July) 1944.

435. Moore, J. R.: Bridging of Bone Defects in Compound Wounds, J. Bone & Joint Surg. **26**:455-468 (July) 1944.

436. Snyder, H. E.: War Wounds of the Extremities, M. Bull. North African Theat. Op. (no. 5) **1**:35-36 (May) 1944.

Fruchand [437] criticizes the English method of treating wounds of joints by suturing the capsule, because too often secondary infection develops. He prefers the French method of drainage of joints so that synovial fluid can flush the wound as it escapes. This is done by wide arthrotomy and suture of the synovial membrane to the skin. In the knee, it is simple to achieve such drainage. However, in the hip, elbow, wrist and ankle, there are bony structures within the joint (head of the femur, olecranon, carpal bones and astragalus) which interfere with proper drainage and which often need to be excised.

Postoperative immobilization is extremely important to prevent spread of the infection or secondary invasion of bacteria. Plaster casts accomplish this better than any other type of splint. [Ed. Note (L. D. B.).—There have been numerous conflicting reports as to the treatment of war wounds of the joints. We shall reserve our opinion until final results are available.]

Carpenter [438] found penicillin to be nontoxic and useful in combating the common infections. For local application, a solution of 250 units per cubic centimeter is used to saturate gauze packs which are inserted into the wound once daily. For the streptococcic and pneumococcic infections, 90,000 to 120,000 units is given daily. For the staphylococcic infections, more than twice this dose is required. In patients with chronic sepsis a negative nitrogen balance develops, and this must be overcome to insure normal wound healing. Hemoglobin deficiency is especially prone to retard healing.

For acute compound fractures use of penicillin should be begun immediately, even before the débridement operation. With this powerful new antibacterial agent it is possible that compound fractures can be saved from infection even ten to twenty-four hours after the accident. Penicillin is a more effectual antibacterial agent than the sulfonamide drugs in both the prevention and the cure of infection.

Forbes and Goligher [439] give a detailed discussion of the case of a 24 year old man who had a compound fracture of the tibia and fibula. The patient received his injuries during a naval engagement. After a month, the fracture wound was still heavily infected, and when the first cast was changed the patient's temperature rose rapidly and signs of septicemia occurred. Chemotherapy was ineffective, and the leg was amputated. Aerobic culture of the blood was sterile, but a gram-negative filamentous organism resembling Bacterium necrophorum was

437. Fruchand, H.: Wounds of the Joints, Lancet **2**:235-238 (Aug. 18) 1944.

438. Carpenter, G. K., and Mech, K. F.: The Role of Penicillin in the Treatment of Compound Fractures, New York State J. Med. **44**:1886-1890 (Sept. 1) 1944.

439. Forbes, G. B., and Goligher, J. C.: Necrobacillosis in Man, Lancet **1**: 399-401 (March 25) 1944.

isolated from pyemic abscesses and was later grown anaerobically from the blood. On the patient's death, after nearly twelve weeks of illness, multiple pyemic abscesses were found in the lungs and under the skin.

Bact. necrophorum is widely distributed and causes a variety of diseases in animals. Though it has been recovered from the healthy human colon and also from the colon in ulcerative colitis, few cases are on record in which it has been clearly pathogenic to human beings. In this particular case discussed, the source of the infection was not known.

King and Brewer [440] discuss in some detail gangrene complicating fractures about the knee. They presented 4 of their own cases which were followed by careful dissection of the amputated foot, the cause of complication in 2 of the cases being thrombosis of the main vessels and in 2 of the cases being actual rupture of the vessels. There were 2 cases with fracture of the upper portion of the tibia, 1 of the lower part of the femur and 1 of fracture dislocation of the knee. A careful analysis of the dissection was carried out in each case and indicated that the blood vessels at the knee were particularly susceptible to damage owing to their close proximity to the bone and to their complete immobilization. The extreme importance of early recognition is emphasized, particularly the effort to distinguish between thrombosis and rupture. They believe that exploration should be carried out immediately if rupture is diagnosed, since delay will add to the danger of increased gangrene and increased fatality. Operation, as a rule, is ligation rather than repair of the vessels indicated. On the other hand, should thrombosis be diagnosed, therapy should be instituted toward support of the ischemic tissue by advancing the collateral circulation. In any event, early and prompt reduction of the deformity is essential and should be carried out with the patient under anesthesia. Lumbar sympathetic block should be considered as an aid to circulation and repeated as often as indicated. Local heat should be applied only after careful consideration of the metabolism of the affected part. Drugs also will be of help. Amputation is carried out as soon as demarcation occurs. [ED. NOTE.—This is an excellent study of this problem and merits careful reading of the original article.]

West [441] advocates three methods of treatment of compound fractures of the femur: (1) slinging of the injured limb in the Thomas splint with Pearson attachment and with skeletal extension (this method is the one he uses widely); (2) immobilization of the injured limb in an ordinary Thomas bed knee splint with fixed adhesive skin traction

440. King, J. M., and Brewer, B. J.: Gangrene Complicating Fractures About the Knee, Surg., Gynec. & Obst. **78**:29-35 (Jan.) 1944.

441. West, E. F.: Treatment of Compound Fractures of Femur in Battle Casualties at General Hospital, M. J. Australia **1**:193-196 (March 4) 1944.

(this method is advocated in cases in which wounds interfere with the use of the Steinman pin and in some transverse fractures), and (3) immobilization of the injured limb in a single or double hip spica (this is used in cases in which considerable loss of bone has occurred and bone contact must be maintained by shortening and in cases in which ankylosis is desired in the optimum position). The author describes each method in considerable detail.

The results of treatment in more than 500 cases of war fractures of the femur are reviewed by Yudin.[442] He advocates well performed, thorough débridement, intense local and general hemotherapy and closed plaster cast. This method is used even in the presence of well developed infection.

The operative principles are: (1) wide excision of all injured and contused tissue, regardless of the presence of infection; (2) no drains; (3) continuous free drainage by means of counteropenings; (4) suture of the edges of the skin with surgical gut to the deep fascia; (5) rich abundant lavage of the wound with a mild soap solution, and (6) local chemotherapy and a closed nonpadded plaster of paris cast. An hour and a half is allowed for each patient. Three tables are set up. On the first table traction is applied, spinal anesthesia is given and the wounded man is washed. On the second table the operation is performed, and on the third the cast is applied. The mortality in over 500 cases was 5.9 per cent. Yudin credits Piragoff with first having used plaster in treating war fractures.

Cantril and Buschke[443] report 9 cases of gas gangrene successfully treated by roentgen therapy with or without therapy with sulfonamide compounds. Two treatments daily for several days were the usual dose varied according to the severity of the original infection.

Two of the patients recovered without need for amputations, 1 required an amputation eighteen months later and 4 required amputatations because of circulatory damage.

The authors feel that sulfonamide drugs are of no benefit in controlling the progress of gas gangrene infection. [Ed. Note.—This report is more optimistic and more credible than some others on roentgen therapy for gas gangrene. As is well known, the outcome often depends more on whether the infection is in the fascial spaces or in the necrotic muscle than on the therapy used. Many physicians have felt that sulfonamide drugs were effective against the gas-producing anaerobes. At any rate, all this discussion will be altered one way or

442. Yudin, S. S.: Treatment of War Fractures of Femur, Surg., Gynec. & Obst. **78**:1-8 (Jan.) 1944.

443. Cantril, S. T., and Buschke, F.: Roentgen Therapy in Gas Bacillus Infection, Radiology **43**:333-345 (Oct.) 1944.

the other when the final evidence on penicillin therapy has been published.]

Orr-Ewing and colleagues [444] report a study of 32 patients with severe compound wounds, 18 of whom received sulfanilamide locally and 14 of whom did not. None of the patients received general sulfanilamide treatment. Direct bacteriologic examination of the wounds during treatment showed that for the first two weeks the sulfanilamide-treated wounds contained fewer bacteria than the controls. After two weeks there was little difference between the two groups. There was no clinical evidence that local sulfanilamide therapy affected the course of the infection. The wound flora was reduced, but there was no corresponding benefit to the ultimate result of the wound. [ED. NOTE.—These observations annul many of the beliefs of the early enthusiasts for local sulfanilamide therapy of compound wounds. Yet this is apparently a thorough study. The whole issue becomes less important, however, from the fact that general penicillin therapy seems destined to displace therapy with sulfonamide drugs in compound injuries.]

Kepl, Ochsner and Dixon [445] report a case of gunshot injury of the thigh and a case of severe laceration of the upper extremity in each of which clostridial infections developed. In the first case treatment consisted in local application of calcium penicillin, and in the second local and general treatment was used after the arm was amputated.

In addition to prompt surgical treatment, the use of penicillin caused a rapid drop in toxic symptoms, and the wounds progressed to comparatively prompt healing. The authors make it clear that a good operation is still the prime essential to successful treatment of gas gangrene.

Furlong and Clark [446] studied 140 compound fractures of the femur, 70 treated with penicillin and 70 treated by other methods. Penicillin was not used locally, but 15,000 units was given intramuscularly every three hours for three days and every four hours for two additional days. There were 7 deaths, 6 in the control series and 1 in the penicillin series. Eight thigh amputations were performed, 6 in the control series and 2 in the penicillin series. Penicillin as used in this series failed to control sepsis fully and did not diminish the incidence of chronic infection. Penicillin is not a substitute for surgical treatment. Closure of compound wounds is undesirable unless adequate drainage

444. Orr-Ewing, J.; Scott, J. C.; Masina, F. H.; Trueta, J., and Gardner, A. D.: Local Sulphanilamide Treatment of Fresh Wounds in Complete Plasters, Brit. J. Surg. **32**:83-84 (July) 1944.

445. Kepl, M. F.; Ochsner, A., and Dixon, J. L.: Two Cases of Clostridium Welchi Infection Treated with Penicillin, J. A. M. A. **126**:96-98 (Sept. 9) 1944.

446. Furlong, R., and Clark, J. M. P.: On the Use of Penicillin to Control Infection in Open Fractures of the Femur, Brit. J. Surg. (supp.) **32**:147-154 (July) 1944.

is provided. [ED. NOTE.—This interesting experiment, which was well controlled, confirms once again the point that penicillin is just an adjuvant to surgical treatment in compound fractures.]

Brown [447] shows graphically how the best repairs of bones and tendons often fail because of defective skin covering the damaged areas. Sclerotic skin with poor blood supply makes an extremely ineffective barrier to outside infection. Recurrent ulceration over a fracture or bone graft is an invitation to failure. Hence the advice of this eminent plastic surgeon on the use of skin grafts over scarred areas is well worth heeding.

March Fractures or Fatigue Fractures.—Jones [448] presents 3 cases of march fracture of the inferior pubic ramus. Such fractures are characterized by absence of trauma and absence of any other break in the pubic ring. In all these cases there were insidious onsets, with pain in the adductor region of the thigh. The fractures did not respond to physical therapy, and roentgenograms revealed rarefaction and surrounding periosteal reaction along the inferior pubic ramus. Treatment consisted in simple rest in bed.

The fractures were found in young trainees, who previously had led a sedentary existence, and not in the older, conditioned soldiers.

Jones concludes that in the presence of pain in the adductor muscles, the hip or the pelvis a roentgenogram of the pelvis should be a part of the examination, and he believes that this injury would be found frequently in the armed forces if it were sought.

Hamilton and Finklestein [449] report a case of march fracture involving the lower extremities of both fibulas. This is another addition to the voluminous recent literature on march fractures, describing them as occurring at practically any location where there can be unusual stress and strain on a bone. It is the authors' opinion that the condition is due entirely to overstrain.

March fractures are not rare but are reported under many other names, such as pseudofracture, wear and tear fracture, callous tumors and fractureless callus. Branch [450] observes that in the first stage there is vague pain, usually diagnosed as of muscle origin. Roentgenograms may show no evidence of fracture at first, but they should be repeated every ten or fourteen days. In the second stage there may be circumscribed pain and pitting edema over the bone. Roentgenograms reveal

447. Brown, J. B.: Surface Repair of Compound Injuries, J. Bone & Joint Surg. **26**:448-454 (July) 1944.

448. Jones, D. B.: March Fracture of the Inferior Pubic Ramus, Radiology **41**:586-588 (Dec.) 1943.

449. Hamilton, A. S., and Finklestein, H. E.: March Fracture: Report of Case Involving Both Fibulae, J. Bone & Joint Surg. **26**:146-147 (Jan.) 1944.

450. Branch, H. E.: March Fractures of the Femur, J. Bone & Joint Surg. **26**:387-391 (April) 1944.

periosteal thickening and eventually densities and rarefaction in the bone structure. Three cases of march fracture of the neck of the femur and 1 of the shaft are presented.

Proctor, Campbell and Dobelle [451] report 7 cases of march fracture of the tibia and 1 of the femur seen in a three month period at a station hospital. The authors decry the tendency to misdiagnose these injuries as Garré's osteitis, periostitis, osteogenic sarcoma, bone syphilis and tuberculosis.

The patients were found to be of the tall, fair, Nordic type, with an average age of 19 years and 8 months. The mode of onset was sudden pain followed by lameness occurring during exercises. Serum calcium levels were consistently low. Treatment consisted in palliative physical therapy and cessation of rigorous activity. Casts were not applied.

Klass and Farrell [452] report that fatigue fractures occur more often than they are recognized, that they cause callus formation that is often confused with tumor growth and that the treatment is simple and conservative.

The authors report in detail on 8 fatigue fractures of the shaft of the tibia. All followed arduous activity and were not recognized, as a rule, until two to eight weeks after onset of symptoms. Vague aching pain and sharply localized tenderness were the most prominent symptoms. Most of the fractures occurred at the junction of the middle and upper thirds of the tibia.

The authors prefer the name "gradual fracture" for this condition since it more accurately describes the mode of occurrence. Treatment usually consists in rest in bed for three weeks followed by wearing of an elastic bandage and light duty for four weeks.

Ross [453] reports his use of the Stader splint at the Camp Borden Military Hospital on 28 patients. His staff studied the use of the splint on cadavers for a week before adapting it clinically. This probably accounts for the successful results obtained in this group of cases. There were no deaths, no infections, 1 nonunion and better joint and muscle function. "Pin seepage" and "ring sequestrums" were eliminated by use of a new type of pin, which could be drilled through the bone more easily. It was also found that better control of fragments could be obtained if the pins were placed close to the fracture line. Reimpaction of fragments at ten and at twenty days was found to be most important to prevent nonunion. [ED. NOTE.—These surgeons have done better with the Stader splint than many surgeons.]

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451. Proctor, S. E.; Campbell, T. A., and Dobelle, M.: March Fractures of Tibia and Femur, Surg., Gynec. & Obst. **78**:415-418 (April) 1944.

452. Klass, A. A., and Farrell, W. A.: Fatigue Fractures of the Tibia, J. Canad. M. Serv. **2**:25-36 (Nov.) 1944.

453 Ross, J. W.: External Fixation in Fractures, Canad. M. A. J. **51**:543-546 (Dec.) 1944.

Shaar and Kreuz [454] report on 110 patients with fractures treated at the Philadelphia Naval Hospital with the Stader splint. Of these, 107 were returned to duty and 2 obtained nonunion. There were eleven fractures of the femur, forty-four fractures of the tibia and fibula, fourteen of the os calcis and ten of the humerus.

There was "pin seepage" in 10 per cent of the cases and only one frank infection about a pin. There was one instance of formation of a "ring sequestrum." There were two nonunions and 2 cases of undue bowing. [ED. NOTE.—The morbidity reported in this series is unusually low.]

Wenger [455] has devised two plates and four bolts of vitallium which can be placed across a fracture to provide secure immobilization. No external fixation or splint is required. [ED. NOTE.—This is much more stable than the usual single plate and screws. Nevertheless there is still danger of motion in a fracture of the shaft of the femur, no matter how secure the plate fixation. We have seen nonunion develop when two plates were applied, simply because motion could not be entirely prevented.]

Sava [456] describes a simple overhead wooden frame to be used for suspending an arm or leg while a cast is being applied. [ED. NOTE.—This resembles Magnuson's suggested small sawhorse for the same purpose. They are useful in the office or in hospitals.]

Lord and Coutts [457] report that the surgeons at the parachute school at Fort Benning have so improved methods of teaching that students now have less than a 1 per cent chance of being injured in a single jump.

In preliminary physical hardening, the most usual accident is tear of the right rectus abdominis muscle. This follows rope climbing and is often confused with the diagnosis of acute appendicitis.

In the tumbling training, acromioclavicular separation occurs if the landing is improper and the point of the shoulder strikes the ground.

In landing with the feet apart, fractures of the ankle often occurred. Now, however, with the improved method of landing, with the feet together, fractures more often occur in the upper end of the fibula.

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454. Shaar, C. M.; Kreuz, F. P., Jr., and Jones, D. T.: End Results of Treatment of Fresh Fractures by the Use of the Stader Apparatus, J. Bone & Joint Surg. **26**:471-474 (July) 1944.

455. Wenger, H. L.: Shaft Fracture Immobilization Without Plaster, Am. J. Surg. **66**:382-383 (Dec.) 1944.

456. Sava, A. F.: An Aid in Casting of Fractures, Am. J. Surg. **66**:136-138 (Oct.) 1944.

457. Lord, C. D., and Coutts, J. W: A Study of Typical Parachute Injuries Occurring in 250,000 Jumps at the Parachute School, J Bone & Joint Surg. **26**: 547-557 (July) 1944.

All these injuries have been successfully combated by alterations in methods of teaching, so that parachute training is becoming increasingly safe.

In military surgery, Olson [458] reports, tantalum has been used to make skull plates, ear frameworks and nerve sutures and to fill defects in jaws. The element tantalum was identified by Eckeberg in 1803, but the purified metal was extracted first by von Bolton in 1903 for light filaments. In 1936, Burch, Carney and Burke experimented with tantalum plates in laboratory animals. Their work led to its clinical use in the form of wires, plates and foil. [ED. NOTE.—This article gives elaborate descriptions of the metallurgic and chemical features of tantalum. It reveals the present uses of the metal in surgery. Bone plates and screws, however, have not been successfully produced from this element. Consequently, the Fracture Committee of the American College of Surgeons has declared that with present knowledge of the material, it is not suitable for plates and screws for use on long bones.]

XIV. Conditions Involving the Spine and Thorax, Exclusive of Those in the Lower Part of the Back

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THERE was a great decrease in the number of articles on conditions involving the spine and the thorax in the 1944 literature as compared with that of previous years, and only a few articles contain any real progress in orthopedic surgery.

Anatomic Variations.—Walker [459] present 3 cases of myelodysplasia associated with a dilatation of the spinal canal at the site of the anomaly and a case of vascular abnormality, angioma and aneurysm of the spinal cord accompanied with enlargement of the spinal canal at the site of the lesion. He discusses the roentgenographic and pathologic manifestations of myelodysplasia and points out that, although neoplastic conditions cause most instances of roentgenographically demonstrable enlargement of the spinal canal, congenital abnormalities of the spinal cord should be considered as etiologic factors.

He believes that enlargement of the spinal canal in these cases presumably occurred early in the development of the person, probably at the time the ossification centers were laid down. Since, except for the last case, there was no evidence of compression of the spinal cord either by lumbar puncture or at the time of operation—in fact, in the first 2 cases

458. Olson, C. T.: Tantalum—A Glimpse of Its Surgical Future, Indust. Med. **13**:738 (Sept.) 1944.

of myelodysplasia there was much more room in the subarachnoid space than usual—if his assumption is correct it must then be assumed that the segments of the spinal cord did not change their position relative to the vertebral column, as normally occurs. At 3 months of intrauterine life, the segments of the spinal cord correspond anatomically to the vertebral segments, but normally at birth the lower end of the spinal cord lies at the third lumbar vertebra and in adult life at the first lumbar vertebra. In the lumbar region of the spinal cord, where most of the myelodysplasias occur, this lack of upward migration will cause considerable tension on the spinal cord, the main reason for symptoms developing early in adult life. The author states that although the enlargement of the spinal canal has been noted in some autopsies it has not been recognized generally by clinical neurologists or roentgenologists. He points out that in discussing the roentgenologic aspect of spina bifida occulta Dietrich does not refer to dilatation of the vertebral canal and that in Elsberg and Dike's paper on enlargement of the spinal canal no mention is made of myelodysplasia as a cause of such dilatation. Also, Pancos, Pendegrast and Shaffer do not refer to it. He feels that, while it might be assumed that the dilatation of the canal associated with congenital anomalies could be distinguished from that due to intraspinal neoplasm by the appearance of the pedicles, in a case of enlargement due to congenital maldevelopment the pedicles might not be so eroded or thinned as in a case in which local pressure causes the dilatation; however, such a differentiation does not seem to be possible, for the pedicles are thinned in the present series of cases.

Cohn [460] points out that congenital absence of a single rib is an infrequent occurrence and congenital aplasia of two or more consecutive ribs unilaterally is a rarity. Such a deformity may be present without other anomalies or is found more often in conjunction with defects of the pectoral muscle, of a vertebra or of the position of the scapula. He briefly reviews the literature on the reported cases of congenital absence of ribs. He believes that the association of aplasia of ribs with defect of the vertebral body is explainable on the basis of embryology and describes the development of the vertebral arch and the ribs. He concludes that the intimacy of the primordium of a rib and its corresponding vertebra is thus clearly shown from its embryologic standpoint. He feels that while Ritter and Eppinger believe that the defect of ribs is caused by the pressure of an arm against the thoracic

459. Walker, A. E.: Dilatation of the Vertebral Canal Associated with Congenital Anomalies of the Spinal Cord, Am. J. Roentgenol. **52**:571-582 (Dec.) 1944.

460. Cohn, B. N. E.: Congenital Absence of Ribs, Am. J. Roentgenol. **52**: 494-499 (Nov.) 1944.

cage and although this hypothesis was favored by Thomson and Kienboch—the mechanical mechanism being considered because the arm could be placed in a hernial defect in the thoracic wall—it is impossible to conceive that an arm could remain in one position sufficiently long during intrauterine life to suppress the development of ribs either partially or totally. Moreover, the frequent association of rib defects with vertebral anomaly entirely vitiates this hypothesis. The theory of embryonic adhesions is, likewise, highly untenable.

Cohn reviews the studies of Stockard, who worked with the egg cells of killifish (Fundulus) and advanced an explanation for malformation. Stockard asserted that there are critical moments in the development of every organ or part which are characterized by a rapid cell multiplication. At such times, this particular proliferating lesion may exert a depressive influence over the growth of other parts. If this favorable moment of differentiation is not taken advantage of, the transient supremacy of the part is lost and it, in turn, submits to depression by other parts assuming their dominant period. The result is a reduced or an imperfectly formed region which, having lost this opportunity, is never able to express itself completely or perfectly in competition with other parts now arrived at similar states of preferment. Each organ or part, therefore, not only originates from a definite primordium but also arises at a definite moment that must be utilized by them if ever. According to Stockard's theory, the factor which operates most frequently in these defects is changes in the conditions, moisture, temperature and oxygen supply. Cohn feels that this theory appears to be the most tenable one for the explanation of aplasia of ribs and associated vertebral anomalies when present.

[ED. NOTE.—This is an interesting discussion of the problem of congenital absence of ribs, and the author gives a list of thirty-one references on the subject, although he does not go into the question of scoliosis or its relation to the absence of ribs.]

March [461] reports 2 cases of an apparently hitherto unreported vertebral anomaly, probably a persistent neurocentral synchondrosis, with some associated slight changes. In both of these cases the findings were incidental and had produced no symptoms, and in the two the same type of radiolucent line separating the upper left lateral corner of the body of the vertebra was noted. In both instances, the affected vertebra was associated with some abnormality of the intervertebral disk just beneath it. In discussing the interpretation of the appearance described in these 2 cases, March points out that it must be either an acquired defect, such as a fracture, or a developmental anomaly. He gives a brief consideration of the ossification of the vertebra and,

461. March, H. C.: Vertebral Anomaly: Probable Persistent Neurocentral Synchondrosis, Am. J. Roentgenol. **52**:408-411 (Oct.) 1944.

while he admits that the fact that this radiolucent line runs diagonally caudad through the superior posterior-lateral aspect of the vertebral body instead of vertically through it is the chief objection to concluding that it represents a persistent ununited neurocentral synchondrosis, he believes that it is a developmental anomaly.

Knutsson [462] presents an interesting study on variations in form and volume of the vertebral canal in lordosis and kyphosis and their significance in myelographic diagnosis. This is an excellent article with especially good reproductions of roentgenograms and anatomic drawings to illustrate the point brought out by the author. He shows by means of myelograms that in lordosis the narrowing of the vertebral canal has also caused a narrowing of the dural sack and that this narrowing decreases in kyphosis.

He found in lordosis a general narrowing of the vertebral canal on a level with the intervertebral spaces, principally of the fourth to the fifth lumbar spaces and the fifth lumbar space to the sacrum, was caused by increased protrusion of the intervertebral disk and the ligamentum flavum.

[Ed. Note.—While this article was published in 1942, it was not reviewed previously under "Progress in Orthopedic Surgery." It seems worth mentioning, however, since it is of interest in the problem of protrusion of the intervertebral disk, that a flat back with a tendency to kyphosis is so frequently seen during the early stages and that later, when the disk has become completely sequestrated, there may be a return to the normal lordosis and a loss of the previous flat back.]

Roentgenographic Technic.—Cornwell,[463] in an excellent article on roentgenographic technic for examination of the lumbosacral junction, describes the experimental roentgenologic technic in various angles and positions and discusses the anatomic and the technical considerations and the technic of examination. He gives complete charts of each technic for each position and examination of the patient from different angles. The reproductions of the roentgenograms are remarkably clear, showing excellent detail of the bone, and the photographs are most satisfactory, illustrating the various positions for examination of the lumbosacral area.

[Ed. Note.—While much of the material in this article has been discussed in previous articles, it is an excellent reference, covering the subject well, and is worth reviewing by many orthopedic surgeons,

462. Knutsson, F.: Variations in Form and Volume of Vertebral Canal in Lordosis and Kyphosis: Significance in Myelographic Diagnosis, Acta radiol. **23**:431-443, 1942.

463. Cornwell, W. S.: Lumbosacral Junction, Radiog. & Clin. Photog. (no. 3) **19**:58-69, 1943.

roentgenologists and technicians who are interested in the roentgen ray study of the lumbosacral area.]

Ankylosing Spondylitis.—Fletcher [464] states that the incidence of ankylosing spondylitis, once considered a rare disease, appears to be increasing and a good many cases are seen in the armed services. He reports 68 cases which he includes in the general group of von Bechterew, Strümpell and Pierre Marie, excluding the other cases of spondylitis, due to specific types of organism and osteoarthritis of the spine, which he feels is more correctly termed "spondylosis."

In this group of 36 men, 21 had sedentary occupations while 15, including 5 soldiers, did manual work. Of the 32 women, 13 were housewives, 7 domestic workers, 3 nurses and 9 office workers. The average age at the time of diagnosis was 38.4 years for men, and 40 for women. In the cases of the men, the average time between the onset of symptoms and the time of diagnosis was 2.9 years and in the cases of women 2.5 years.

Fletcher divided the patients into two groups: those with symptoms for less than a year (23) and those with symptoms for more than a year (28). The author also concludes that there is a far greater incidence of the disease in the lumbar portion of the spine in young men. He points out that most reports have stated that this disease is predominantly in men; however, in this series there were 32 women. The author feels that the disease, as seen today, includes features of both the older types, of von Bechterew and Marie-Strümpell, and it is uncertain why such clinical observers should have described only cases of one kind or the other.

In his roentgenographic studies, Fletcher includes the cases of only 65 patients, as 3 patients did not have adequate roentgenologic check-up. He divides them into four groups: (*a*) sacral focus only (17 cases); (*b*) sacral focus and involvement of spine (10 cases), and (*c*) ankylosed sacroiliac joint and involvement of spine (30 cases).

He found no significant variations in sex distribution, sedimentation rate, age, length of history, treatment or prognosis among these groups. He also feels that the erythrocyte sedimentation rate is not of great value in prognosis. Some patients do well in spite of a rising value and vice versa. An erythrocyte sedimentation rate of 15 mm. an hour being taken as raised, 27 of the 36 men and 17 of the 32 women had a raised rate. If 10 mm. an hour is taken as the top limit of normality, 33 of the 36 men and 22 of the 32 women showed a high erythrocyte sedimentation rate.

He classified 8 of the cases in a separate group, in which the disease clinically resembled ankylosing spondylitis with a sacral focus.

464. Fletcher, E.: Ankylosing Spondylitis, Lancet **1**:754-756 (June 10) 1944.

In this group, the average age at the onset of symptoms was 43 and at diagnosis 46. In 5 cases the onset was in the 40 to 50 age group. There were 5 women and 3 men; the site of the attack in all the women was in the cervical area and in 3 men in the dorsal region.

The author points out that it is hard to estimate the value of treatment in a condition subject to remission, but certain measures are clearly beneficial. He feels that roentgen ray treatment cures some patients; the Kromayer lamp has a favorable effect in most cases; gold compounds have apparently been of use; the plaster bed is helpful, and physical methods play an important part in all cases, especially those in which there is diminished respiratory excursion. He does not mention the use of support, such as back braces.

[ED. NOTE.—This is an interesting paper, but the author does not go into much detail on the matter of treatment and does not discuss the use of braces, the importance of prevention of deformity or the more recent use of osteotomy of the spine for correction of very severe deformities. It is also noted that he does not point out, as other authors have done, that the roentgen ray treatment is primarily for the relief of pain and is of value mainly in the early stages.]

Scoliosis.—Bickel, Hinchey and Clagett [465] report the treatment of 10 patients with severe scoliosis by means of rib resection and immediate fusion of the spine. They state:

> In treatment of scoliosis the primary consideration of the orthopedic surgeon is the arrest of the progress of the spinal curvature. In some cases of thoracic scoliosis a secondary problem presents itself, namely the cosmetic deformity of the back. . . .
>
> In the last twelve years the procedure of rib resection with use of the removed segments of ribs to fuse the vertebrae has been performed in ten cases at the Clinic.

The procedure is described as follows:

> The patient is first placed under 6 pounds (2.7 Kg.) of traction to the head and feet on a curved hyperextension frame for seven to ten days. The apex of the traction corresponds to the point of greatest convexity of the spinal curve. Rib resection and spinal fusion then are done as one procedure, the former by a thoracic surgeon and the latter by an orthopedic surgeon. The two previously discuss and agree on both the number and extent of ribs to be resected and the number of vertebrae to be fused. The entire procedure can be carried out through one long incision over the spinal column but more frequently two incisions are used, one over the convexity of the ribs and a parallel straight incision exposing the vertebrae to be fused. The ribs are resected subperiosteally throughout the extent of the prominence. The resected portions are split lengthwise and placed along the concave side of the spinal curve next to denuded laminae and spinous processes; their own curve frequently corresponds to that of their spinal bed and they may be broken in a green-stick fracture for even closer coaptation.

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465. Bickel, W. H.; Hinchey, J. J., and Clagett, O. T.: Treatment of Severe Scoliosis with Rib Resection and Immediate Fusion of Vertebrae, Proc. Staff Meet., Mayo Clin. **19**:401-424 (Aug. 9) 1944.

They are placed in an overlapping double row throughout the extent of the curve and held in place by closure of the overlying muscles and fascia. There is always more than enough bone for use as grafts. Following operation the patient is placed for two weeks on a straight Bradford frame and is turned from the prone to supine position and vice versa at regular intervals. The use of the previously mentioned traction and hyperextension frame is resumed for four weeks. At the end of this period a plaster body jacket is supplied with the patient on a Goldthwaite frame. The patient is permitted to be up and around for a week; the cast then is removed and another which extends from the occiput and chin to include the iliac crests is applied with the patient in upright suspension. This cast is worn for four months after which it is replaced by a corset or brace which is worn for six months. At the end of this six months such activities as swimming and breathing exercises are started and the corset or brace is discarded gradually; there is then a progressive return to normal activity . . .

Bickel and his colleagues report that in 3 cases the operations were complicated by pleural effusions. No other complication occurred in this series, nor was there a fatality. The patients withstood a rather extensive operation well. If after the resection of the ribs further operation is not thought advisable, the ribs can be preserved by refrigeration and used at a subsequent operation for grafting of the spinal column.

The authors state that roentgenograms of the ribs six months after the operation showed remarkable osseous regeneration from the periosteum of the resected ribs; this regeneration conformed to the new contour of the thoracic wall. Clinically, the thoracic cage was rigid after about six months.

[ED. NOTE.—Since many surgeons are attempting major operations on patients with scoliosis and since Bickel believes that in selected cases, in which the deformity of the thoracic cage is severe enough to warrant it, rib resection with immediate use of the ribs to secure spinal fusion is the procedure of choice, it seems desirable to consider a few points in this problem.

First, 10 cases (really only 7 cases followed beyond six months) are not sufficient for satisfactory conclusions, and so few cases have been reported in the literature that the value of the procedure is still debatable.

Second, most of the patients were evidently beyond the age of 15, the average age being 16, and, since only 1 case was due to poliomyelitis, the disease in these patients had apparently already stopped progressing and the curves would not have increased if they had not been fused. As idiopathic scoliosis rarely increases in girls after the age of 15 and in boys after 16, one has little proof that this procedure really stopped the progress of the curve in these cases; the scoliosis in 2 actually increased.

Third, since in 2 of the 7 cases the curve increased and in the others remained stationary or improved only slightly, no significant improvement in the curve can be expected from this procedure.

Fourth, it would seem, therefore, that the only improvement to be obtained from this procedure is a decrease in the prominent angulation of the ribs on the convex side of the curve or razorback deformity and that the success of the procedure is difficult to evaluate. In the discussion Bickel states that "since the majority of these patients are adolescent girls, the most frequent complaint when they are seen is the developing deformity" and "if the deformity can be corrected to some extent and the scoliosis arrested by spinal fusion in the same procedure without undue risk to the patient, I can see no objection to this type of surgical procedure," and "in selected cases in which the deformity of the thoracic cage is severe enough to warrant it, I believe that rib resection with immediate use of the ribs to secure spinal fusion is the procedure of choice." These statements tend to encourage the inexperienced orthopedic surgeon to use this procedure for adolescent girls with increasing curvatures. While it is possible that this procedure might be considered in certain cases in which the angulation of the ribs was already severe and in which the curve was increasing rapidly and a decrease in the prominence of the ribs and the arrest of the progress could be expected following a solid fusion, most orthopedic surgeons who have had considerable experience in the correction and fusion of idiopathic scoliosis feel that such pronounced improvement in the curve can be obtained by correction and fusion if done early enough; they feel that usually the rib resection is not indicated or that if it is it should be done only after the maximum correction of the curve is obtained and secured by a solid fusion of the spine in adolescent patients whose curvatures are increasing.

Fifth, it should be noted that resection of ribs, being a thoracoplasty procedure, tends to produce a curve convex to the same side, so that in the younger patients especially one would be adding a factor of possible increase in the curve if the ribs on the convex side are resected and the spinal fusion is not sufficiently solid. Patients with severe scoliosis usually have considerable decrease in the vital capacity and, unless there is little or no pulmonary tissue under the severely angulated ribs of a razorback area, some further decrease in the vital capacity should be expected after the ribs in that area have been resected. Is this desirable in a patient who already has decreased vital capacity as a price for uncertain cosmetic improvement? One must also consider how much cosmetic improvement could be expected from the removal of only three to six ribs, as in most cases of severe scoliosis more than six ribs are involved and the prominence of the transverse processes and the severe rotation make it impossible to obtain a satis-

factory correction. In several of our cases, extensive rib resection long after a solid fusion of the spine was obtained did not result in sufficient further improvement to warrant the procedure in our opinion.

Sixth, if there is any indication for this procedure it would seem to be in a case of scoliosis in which little if any correction could be expected, usually in scoliosis not progressing and too old or rigid to get correction and in a patient for whom one wanted only to decrease the prominence of the ribs and at the same time stabilize the spine and prevent any tendency of the curve to increase after the rib resection.

The indications for the procedure would therefore seem to be exceedingly rare and when present should have the careful consideration of one experienced in the problem of scoliosis before being attempted.]

Pleurodynia.—Kelly [466] reviews the literature and discusses the problem of pleurodynia and intramuscular fibrositis and the use of local anesthesia as an aid in the study and the treatment of patients with pain in the chest. He refers to the opinions of Stockton, Ray, Lewis and Kellgren and others in earlier reports and discusses the mechanism of thoracic pain and the rationale of its treatment. He feels that observations suggest that somatic and visceral lesions may be linked in an association more intimate than is generally suspected and believes that it is likely that the muscles will prove to play a large part in the mechanism of the production of the spontaneous pain of disease. The author believes that the essence of pleurodynia is a painful lesion of the muscles surrounded by a fibrositic reaction and that in the marjority of cases a cure will result from the infiltration of the lesion with a local anesthetic agent. He also believes that when pain in the chest is associated with physical kinds of disease of the lungs or the pleura, the pain can often be relieved in the same fashion. He reports successful results in 35 cases. He gives 9 case reports to illustrate various points, 1 especially to disprove the common belief that the pain of dry pleurisy is due to the rubbing together of two surfaces roughened by fibrous exudates, for in this case the pain was relieved by 1 cc. of local anesthetic injected into the tender spot, although the friction rub of the pleurisy continued for three days.

Lesions of Disks.—Downing [467] states that while several cases have been reported of injury to the intervertebral disk by lumbar puncture followed by persistent pain in the back and roentgenologic evidence of collapse of the disk, the direct relationship still remains in dispute. He reviews the literature and points out that in 1919 Levinson stated

466. Kelly, M.: Pain in the Chest: Observations on the Use of Local Anaesthesia in Its Investigation and Treatment, M. J. Australia **1**:4-7 (Jan. 1) 1944.

467. Downing, F. H.: Collapse of Intervertebral Disc Following Spinal Puncture, U. S. Nav. M. Bull. **43**:666-673 (Oct.) 1944.

that the spinal puncture needle if inserted too far might dislodge the ligament from the nuclear material, which would account for failure to obtain spinal fluid. Pease, doing experimental lumbar punctures on cadavers, found that it was not always possible to determine when the point of the needle entered the neural canal, passed it or entered the intervertebral disk. Munro and Harding, in reviewing the needle technic in myelography, allowed the needle to remain in place while lateral roentgenograms of the spine were made. They found that of the sixty needles inserted, 36 per cent were in such position that had they been inserted farther in their course they would have penetrated the annulus fibrosus. The average distance between the point of the needle and the annulus was from 4 to 5 mm. Pease also demonstrated that when the torso is flexed in preparation for a lumbar puncture and the needle is inserted in the midline beyond the neural canal it will enter the intervertebral disk; if the body is not flexed, the needle will strike the vertebral body or enter the venous sinusoid or one of the connecting veins. Flexion of the spine increases the intervertebral disk pressure, and, because of the stronger anterior elements of the disk, this pressure is reflected in the weaker or the posterior portion, causing a slight bulging of the disk into the neural canal. The needle, in entering the disk allows the nuclear material to escape into the lumen or around the needle.

Experimental studies by Keyes and Compere led them to conclude that a minor puncture of the intervertebral disk might result in the escape of the nuclear material, pain in the back and disability, partial collapse of the disk and marginal proliferation of the adjacent vertebral bodies. In discussing the mechanism of the injury, Downing mentions that the posterior longitudinal ligament in the lumbar segments becomes narrowed and thus only reenforces the annulus fibrosus in the posterior portion of a small area. He is of the opinion that when the needle point becomes deflected to either side of the midline it may be deflected past the dura without penetrating it and the operator, not obtaining the spinal fluid, continues to advance the needle until finally the annulus fibrosus and the intervertebral disk are penetrated lateral to the posterior longitudinal ligaments. If this is repeated, several punctures of the annulus will occur in this area; the damage may be sufficient to allow the subsequent escape of nuclear material or to precipitate traumatic degenerative changes which finally result in collapse of the intervertebral disk. In the first case reported here, the onset of early symptoms together with long delayed evidence of collapse of the intervertebral disk would indicate that the pain was more likely due to extensive trauma to the disk rather than to the subsequent escape of nuclear substance. Resultant collapse of the disk was purely a later degenera-

tive reaction precipitated by the original trauma; it was also manifested by productive osteoarthritic changes.

In both cases reported here conservative treatment was tried, but apparently the patients were still complaining, and spinal fusion was considered. Roentgenograms from these 2 cases were presented showing no narrowing of the intervertebral disks previous to lumbar puncture and, later, a definite narrowing of the disk involved.

Downing believes that the acutely flexed position of the spine when the puncture is made increases the danger of injury to the disk by increasing the intradisk pressure and directing the needle toward the intervertebral space. The needle should be angulated cephalad so that in case it is inserted too deeply it will strike the posterior surface of the superior vertebra. He suggests the use of a sharp fine caliber short bevel needle and extremely careful technic.

[ED. NOTE.—While numerous cases of collapse of the intervertebral disk following spinal puncture have been reported, this paper presents anatomic considerations and suggestions for avoiding this occurrence. It seems worth while to stress the increasing number of cases of injury to the intervertebral disk following lumbar puncture and to suggest more caution in this procedure.]

Spurling and Scoville [468] (reviewed by Dr. R. Beverly Raney, Durham, N. C.) call attention to the role of the lower cervical intervertebral disk in the production of pain in the shoulder and arm. They review the literature and point out that most reports on ruptures of cervical intervertebral disks have indicated that the lesion is likely to be confused with neoplasms of the cervical portion of the cord. The anatomy of the cervical part of the spine and the spinal cord in this area is discussed. The pathologic changes are described, and the causation is pointed out. A brief description of the symptoms is given. Pain and stiffness of the neck are usually the first symptoms, and generally any sudden movements of the head and neck will produce a feeling of electrical shock in the arm and hand of the involved side. Numbness and tingling may be present. Tenderness to fist percussion at the site of the lesion is a fairly constant observation. They state that the most important diagnostic test which is almost pathognomonic of a cervical intraspinal lesion is the neck compression test, in which the head and neck are tilted toward the painful side and pressure exerted on top of the head; when this test intensifies the pain, the reaction is considered to be positive. In the differential diagnosis the authors mention neoplasms, inflammation of nerves, scalenus anticus syndrome, cervical ribs and bony spur formation in the intervertebral foramens.

468. Spurling, R. G., and Scoville, W. B.: Lateral Rupture of Cervical Intervertebral Discs: Common Cause of Shoulder and Arm Pain, Surg., Gynec. & Obst. **78**:350-358 (April) 1944.

Roentgenograms may show narrowing of the intervertebral space, with loss of the normal lordotic curve. The authors report the cases of 12 patients who had been operated on for ruptured cervical intervertebral disks. All the patients were relieved of radicular pain within two weeks following operation. Spurling and Scoville recommend that during the postoperative period the patient be kept recumbent as long as there is residual pain in the upper extremities or shoulders.

Brooke [469] (reviewed by Dr. R. Beverly Raney, Durham, N. C.) presents a detailed report of a case of complete transverse cervical myelitis caused by traumatic herniation of an ossified nucleus pulposus. The patient was admitted to the hospital with complete flaccid paralysis below the fifth cervical segment and with loss of sensation of all types below the sixth cervical segment. Death occurred fifteen days after admission. Autopsy showed a defective and frayed posterior longitudinal ligament, with posterior protrusion of a calcified nucleus pulposus between the fourth and fifth cervical vertebrae. The cord at this level presented a transverse d pression with softening. It was believed that the symptoms were initiated by trauma, resulting in degenerative changes in the intervertebral disk.

Multiple Intraspinal Lesions.—Ehni [470] reports a case of multiple intraspinal lesions in which part of the clinical picture was caused by a neurofibroma at the level of the conus medullaris and the rest, including the chief complaint, pain, was caused by a protrusion of the fourth intervertebral disk. Myelography demonstrated the existence of the two lesions and made clear a problem that might otherwise have led to an imperfect solution and result.

He reminds the reader that intraspinal tumors, with the exception of protrusions of intervertebral disks, are rather uncommon lesions (the incidence has been 1 in 2,000 registrants at the clinic) and instances of multiple intraspinal tumors are positively rare. There are two diseases in which multiple intraspinal lesions are the rule. One of these, von Recklinghausen's disease, presents multiple neurofibromas of intraspinal nerve roots, together with multiple meningiomas. Syringomyelia is the other disease, but in addition to the syrinx a tumor of the blood vessel is often present. Protrusions of disks are also multiple in a certain percentage of cases. Aside from these conditions, the author was able to find but 3 instances of multiple primary intraspinal lesions in the records of the clinic, although he has no doubt that there are others. In 1 of these cases, the patient had spastic paraparesis. A myelogram with radiopaque oil revealed complete obstruction to the

469. Brooke, W. S.: Complete Transverse Cervical Myelitis by Traumatic Herniation of Ossified Nucleus Pulposus, J. A. M. A. **125**:117-120 (May 13) 1944.

470. Ehni, G. J.: Multiple Intraspinal Lesions: Report of Case, Proc. Staff Meet., Mayo Clin. **19**:489-491 (Oct. 4) 1944.

upward passage of the oil at the tenth thoracic vertebra due to what subsequently proved to be a meningioma. However, in addition, there were multiple protrusions of the intervertebral disk. Removal of the tumor and decompression of the protruded eleventh thoracic disk by laminectomy resulted in complete recovery. The second patient underwent removal of a meningioma from the region of the foramen magnum and returned three years later for removal of a thoracic meningioma. The third patient was operated on for removal of a protruded disk, but when the nerve root was exposed there seemed to be a swelling on it the size of a pigeon egg which proved to be a neurofibroma. In addition to this tumor, there was a protrusion of the underlying disk. Removal of both lesions resulted in relief of all symptoms.

Ehni points out that the danger of attributing a patient's symptoms to a protrusion of a disk when in reality they are due to an unsuspected intraspinal neoplasm is a real one. Usually it is the tumor that is harder to recognize, because the threshold of suspicion is much lower for protruded disks than for intraspinal tumors. In the case he reports there were multiple intraspinal lesions, with a new twist to the problem in that the neoplasm was much in evidence while the protruded disk was less so. He states that the patient had a Froin syndrome, complete manometric block, clinical evidence of a conus lesion and roentgenographic confirmation of the level. The decision to perform myelography was reached because of the nature of the pain. It had been in both legs and subsequently confined itself to the left. This occurrence Ehni believes to be more characteristic of a protrusion of a disk than of a steadily augmentive mass, such as a neoplasm. After a tumor had been removed and the evidence of stricturing of the caudal sac during passage of the catheter was added to the myelographic evidence of a second lesion, the question arose whether or not to remove the two lesions at the same time. It was known that the second lesion existed, but it was not known that the lesion was causing symptoms. It was decided that the safest course would be to postpone its removal until after it was determined that removal was necessary. After a few days it became evident that removal was necessary, and the patient was relieved completely after the second operation.

[Ed. Note.—While the use of an intraspinal contrast medium in cases of suspected disk lesions is still disputed, the possibility of more than one lesion is certainly an argument in favor of it. However, some cases are so typical without much doubt as to the presence of a disk that many surgeons still feel that in these cases exploration for disk lesions should be performed without the use of opaque material, while other cases are sufficiently doubtful to warrant its use.]

Aneurysmal Bone Cyst of the Spine.—Mayer and Kestler [471] report 2 cases of aneurysmal bone cyst of the spine. In the first case the cyst was located in the body of the seventh dorsal vertebra, and in the second case it was in the second dorsal vertebra. In both cases treatment consisted in laminectomy and curetting of the tumor, and the diagnosis was confirmed by microscopic examination. There was improvement in both cases following these operations, although in the second case there were the complications of decubitus ulcers and flexion contractures of the hips and knees. The authors point out that benign neoplasms of the vertebrae large enough to produce extensive neurologic symptoms are extremely rare and regression of such symptoms following operation is still more infrequent. They feel that the recovery in these 2 cases following operation for aneurysmal bone cyst of the vertebrae indicated that, despite the extensive neurologic evidence of damage to the cord, remarkable improvement is possible following operation.

Adolescent Kyphosis.—MacGowan [472] reviews and summarizes the anatomy and physiology of the spine in a paper on adolescent kyphosis. He discusses the mechanics of kyphosis, and he thinks that in every case of adolescent kyphosis the vertebral nucleus is destroyed before the ossification of the vertebral body is complete. This destruction may be caused by failure of the cartilaginous disk to retain a nucleus or by softening of the vertebral body, which allows the nuclear tissues to prolapse into soft vertebral bodies. As soon as this happens, the weight-bearing function is transferred to the bodies anteriorly and the axis of motion to the posterior vertebral elements; increased pressure results at the anterior borders of the vertebral bodies when the spine is in flexion. If the patient is adolescent, the epiphysis will be subject to trauma. Abnormal ossification follows, leaving after a period of increased growth a premature closure of the epiphysis, failure of anterior vertebral ossification and wedged formation of the vertebral bodies.

The author describes three different types: mobile kyphosis, fixed kyphosis and fixed arthritic kyphosis, the mobile stage being the earliest and merging after a variable period into the fixed and fixed arthritic stages. He believes that the tightening of the posterior thigh muscles and the shortening of the hamstrings contributes to the formation of kyphosis and when the back is flexed, as in toe-touching exercises, damage to the dorsal portion of the spine may result. Of 62 cases, tight hamstrings were present in 66 per cent of the mobile type and

471. Mayer, L., and Kestler, O. C.: Aneurysmal Bone Cyst of Spine, Bull. Hosp. Joint Dis. **5**:16-22 (April) 1944.

472. MacGowan, T. J. B. A.: Adolescent Kyphosis, Lancet **1**:211-214 (Feb. 12) 1944.

in 70 per cent of the rigid type. A secondary scoliosis was found in 27.2 per cent of his cases. The author made studies on the blood of several representative patients with the various types and reports no gross deviation from the normal in the organic or the inorganic elements of the serum or corpuscles.

[ED. NOTE.—Only 4 cases are reported which include these hematologic studies and these are hardly enough to conclude that all cases are normal. The author differs with other writers, who report the disease almost entirely in boys, reporting the occurrence of kyphosis in 64 boys and 66 girls. He classifies these cases of kyphosis in five groups on an etiologic basis (asthmatic, endocrine, congenital, apprentice and traumatic), and he illustrates the roentgenologic appearance of the normal spine and the kyphotic spine at various ages.]

(To Be Continued)